The N. C. Agricultural Experiment Station 1907—1908

THIRTY-FIRST ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

Year Ending June 30, 1908

Including Scientific Papers and Bulletins Nos. 197, 198, 199

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N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

STATION STAFF

GEORGE T. WINSTON, President of the College

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W. A. WITHERS.....Chemist
F. L. STEVENS.....Vegetable Pathologist
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R. I. SMITH.....Entomologist
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A. F. BOWEN.....Bursar
C. P. FRANKLIN.....Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION.
WEST RALEIGH, N C

North Carolina Agricultural Experiment Station,
Office of the Director,
West Raleigh, N. C., June 30, 1908.

To His Excellency, Robert B. Glenn,
Governor of North Carolina.

Sir:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1908.

Trusting that this report will prove satisfactory to your Excellency, I am,

Yours very truly,

C. B. Williams,
Director.

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THIRTY-FIRST ANNUAL REPORT

OF THE DIRECTORS OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30, 1908

By the Director

Upon assuming the duties of Director of the Station at the beginning of the year, careful consideration with the different workers was made of plans of all experiments being conducted and of those subsequently inaugurated. In all branches of the Station new and important lines of investigation have been started, and this work in most cases is progressing in a satisfactory manner. Herewith is presented a brief statement regarding the work in progress in the several Divisions of the Station, which is made up partly from the reports of the different workers and partly from observations made by the Director.

DIVISION OF AGRONOMY.

The experimental work of this Division has been materially augmented and strengthened during the year, both by the addition of new lines of work and by the extension of experiments in progress. Much attention is being devoted to a determination of the best fertilizer combinations and the most economical quantities to use per acre; the most prolific varieties; the best methods of cultivation and handling; and the most profitable rotation for corn, cotton, wheat, oats, cowpeas and soy beans, for the conditions of climate and soil under which the experiments are being conducted. Experiments are being carried on to ascertain the best fertilizer and lime treatment for legumes. With oats, varieties are being grown both from fall and spring sowings to determine the relative value of these different sowings and the best varieties to use for seeding at the respective seasons. Much work has been put out to aid in study of the effect of proper methods of seed selection of cotton, wheat and corn upon their prolificacy and yield. This year, the variety tests will embrace a comparison of sixty-eight varieties of corn, thirty-eight of cotton, fifteen of wheat, sixty-two of oats and about fifty of cowpeas and soy beans. In addition to these, variety-distance tests are being conducted with three leading typical varieties of corn and three of cotton to determine the optimum distancing of these when grown under different conditions. In response to a popular demand for information on alfalfa and clover growing, field studies on small plats are being made to determine under what

conditions of soil, fertilization and cultural management these different legumes make their best and most profitable growth. Investigations are being conducted to ascertain the factors which promote the growth of suckers on different varieties of corn, and the relation their undisturbed development sustains to total yield of grain per acre. More than fifty combinations of grasses and legumes are being experimented with to study their comparative value for hay and pasturage. A thorough system of terraces over the whole farm has been laid off and constructed at an expenditure of considerable effort and time.

DIVISION OF CHEMISTRY.

The Chemical Division has maintained a close cooperation with the Biological Division in a study of nitrogen-fixation, ammonification, nitrification and denitrification. In this cooperation the Chemist confines his attention to the chemical analyses, while the Bacteriologist looks after the bacteriological examinations. Efforts are being made to determine the nature, distribution and conditions most and least favorable for the growing of nitrogen-fixing, nitrifying, ammonifying and denitrifying bacteria. In these investigations, an especial effort is made by the Bacteriologist to isolate and identify the bacteria concerned.

DIVISION OF BIOLOGY.

The research work of the Biological Division has progressed actively along the same general course as previously reported, but has been greatly enlarged by the extension of old lines and the addition of new ones. The cooperation which has been maintained by this Division with the National Bureau of Plant Industry in a Plant Disease Survey of North Carolina and in an effort to secure melons of high eating and shipping qualities that could be grown upon land affected with watermelon wilt will be continued, and experiments have been put out on a badly infected field near Auburn. Efforts are being directed largely toward the production by hybridization and selection of strains of melons that will be wilt-resistant. The results obtained along this line during the past year have been exceedingly encouraging, as the wilt-resistant melons, which now comprise practically all that are being worked with, have been found to possess decidedly higher edible and commercial values than has been secured heretofore.

The tobacco wilt experiments which have been conducted for a number of years in the old bright tobacco belt of Granville County, for the purpose of securing wilt-resistant strains of high commercial value, will be continued. Up to this time, the resistance to this disease of about seventy varieties has been determined. On the infected areas native types of tobacco are practically wiped out by the ravages of this disease. Attention is being confined this year in these ex-

periments to a study of six highly resistant strains, the resistance of which was brought out by last year's work. These promising strains which have been developed are two from Sumatra; two from Turkish; one from Italian; and one from local bright leaf tobacco.

The study of fungi or bacteria causing new or little known apple diseases, occurring in the State, have been continued and extended. During the period covered by these investigations, two new diseases have been discovered and several new ones have been described and much information concerning their mode of life, relation of plant growth and best methods of treatment has been worked out and published. For the present in this line of work, attention is being confined largely to morphological and physiological studies of apple rot, canker, leaf-spot and two diseases that affect the twigs, with the hope of evolving practical remedial measures.

In the lettuce drop investigations, by the construction of cold frames on the Station farm, it has been possible to prosecute the work more completely under control conditions. Outdoor experiments are being carried on which are designed to determine the longevity of the vegetative and reproductive parts of the causal fungus in the soil and in the atmosphere; under what conditions the spores infect the leaves; and the resistance of the fungus to treatment by different chemicals in varying concentrations. These experiments are being supplemented by laboratory work. The soil bacteriology investigations in cooperation with the Chemical Division have been enlarged and continued. A large number of organisms have been isolated and studied with a disclosure of the extreme variety of the presence of nitrifying power in most soils worked with. Study is being made of ammonifying organisms and the comparative rate of activity of nitrogen-fixing bacteria in soils and in solutions. Efforts are being directed towards determining the relative availability and acceptability of ammoniacal nitrogen to some of our general farm crops as compared with nitrate nitrogen. During the year, new research work on the development of poisons in milk has been started for the purpose of ascertaining the conditions under which these are produced and to determine from what source bacteria producing the toxins are derived. Attention will be given to an isolation and study of the organisms responsible for the production of these toxic principles. This work, with slight modifications, will be continued. The value of the work of this Division is attested by the large correspondence it maintains with farmers and fruit growers on plant diseases.

DIVISION OF POULTRY.

Work in the main of the Poultry Division has been conducted along the general lines of testing the relative efficiency of different breeds in food utilization, as shown by egg-production and increase in weight; various methods of handling and feeding chickens; and

different styles of incubators and brooders under different systems of management. In the pedigreed breeding experiments which have now been conducted for two years the results seem to indicate an increased percentage of good layers over previous years. With careful and intelligent breeding and selection along the right lines it is expected to secure strains of greater prolificacy; of higher percentage of egg hatching; and of hardier and more robust constitution. Experiments to determine the value of disinfecting incubators and adding moisture artificially have been carried on with six machines. There seems to be a material increase in the percentage of chickens hatched from fertile eggs under these two conditions combined or separately over those hatched made in dry machines, although the incubators used were of the non-moisture type. In this connection it might be mentioned that the poultryman has secured in these moisture and disinfection experiments two hatches which have proven to be decidedly the best ones that have been made during his five years connection with the Station.

Feeding experiments have just been started to test the value of cottonseed meal for poultry feeding, when fed in different quantities and in different combinations in conjunction with corn and wheat bran. A study of the effects of inbreeding in poultry is being made to determine if it can be carried on indefinitely without producing deterioration in the flock in point of prolificacy, size and vigor, if due attention is given to these characters in mating and selecting breeding stock. This work has not progressed very far, but at this time a marked improvement in the laying capacity of many individuals has been noted.

DIVISION OF HORTICULTURE.

The Horticulturist has devoted his attention largely during the past year to outlining and getting started work of an original nature with blackberries and dewberries. At present he is confining his energies chiefly to a study of the causes and best methods of treatment of that fasciculation commonly known as "double flower," to which these are subject wherever grown commercially in North Carolina. The investigations will consist largely of a study of the structure and growth of the fascicle to determine the causes for its formation, whether due to disease, insects, physiological conditions, cultural treatment, soil or weather. The growing of blackberries in this State for market purposes was started in a small way about twenty years ago in the section around Ridgeway. From this modest beginning, the growing of these and dewberries has gradually developed, until to-day the sale of these crops bring thousands of dollars into the communities where this industry is carried on and where a few years ago there were practically no horticultural interests. This

industry is centered chiefly in Warren, Moore, Cumberland, Columbus and Harnett counties, and is established in many cases on soils which are now returning annually in profit per acre fifteen to twenty times the original purchase price of the land. There are thousands of acres of sandy and sandy loam soils located in the coastal plain section of the State which, as they are at present affording little or no income to their owners, may be purchased very cheaply and which might be given over to remunerative blackberry and dewberry culture. At present, one of the most serious drawbacks to the maintenance and extension of this branch of farming is the greatly decreased yield, frequently caused by "double flower" or "rosette." Especially menacing to profitable blackberry growing is the reduced production experienced by many growers. The Wilson blackberry, the only variety grown for general market purposes, because of its appearance, edibility, shipping qualities and its date of maturity, is ordinarily so badly affected with sterility in the large number of abnormally developed flower parts as to suffer usually a reduction of about seventy-five per cent in total yield. The trouble, while not nearly so serious with dewberries, can only be held in check by costly cultural methods, such as cutting off all the young canes immediately after the picking has been finished. The determining of the cause of "rosette" will have wide practical bearing on the working out of remedial measures not only for blackberry and dewberry growers in North Carolina, but for those located in other sections of the country where these are affected with this abnormality of growth.

The work which this Division is conducting on anthracnose and self-sterility in dewberries is fraught with economic features and possibilities.

DIVISION OF ANIMAL HUSBANDRY.

As this is a new Division of the Station, a considerable portion of the time of the Animal Husbandman has been taken up in planning, providing animals and new equipment and getting under way lines of experimentation. No phase of the work has been completed, but all that has been started is being prosecuted as expeditiously as is consistent with expediency. Much effort has been devoted to a study of the effects of feeding cottonseed meal and linseed meal as supplementary feeds to corn to young and thrifty pigs with a mean average of about 100 pounds live weight, during the experiments. These experiments are designed to determine the amounts of cottonseed meal, which may be safely fed in conjunction with corn to hogs; the economy of gains made; and the quality of the pork produced, in comparison with that secured with rations of corn alone and corn and linseed meal combined. With the completion of the first half of the experiment which had been running for ninety days, it was demonstrated that 0.6 pound of cottonseed meal mixed with the other por-

tion of the ration and fermented may be fed safely during this length period in conjunction with corn in the proportion of five parts of corn to one of meal and secure a pound of gain at less than one-half the cost of those obtained by feeding corn alone under the same conditions. A combination of linseed meal with corn in the proportion of one to five produced gains at about one-half the cost of corn fed alone; in other words, this lot by eating a little more than one-third more feed made three and one-third the amount of gain in the same length of time. These experiments which have been conducted with hogs confined in pens will be duplicated, using the same feeds combined in the same way, with hogs allowed to range on different green crops, such as rape, rye, etc., alone and in combinations. Also, cottonseed meal feeding experiments have been started with the mules and horses which are being worked on the farm. During the preliminary periods, after a few days trial, they have been found to eat from one to one and one-half pounds of meal per day with relish.

DIVISION OF DAIRY HUSBANDRY.

A portion of the time of the Dairy Husbandman has been taken up in conducting feeding experiments to determine the relative value of cottonseed hulls and corn stover as roughages; and dried brewers' grains, and crushed corn in conjunction with cottonseed meal as concentrates with corn stover as the sole roughage for milk and butter production. The first part of these experiments has been finished and show that inferior corn stover, which product is usually left in the field to rot, still had a feeding value for dairy cows equal to that of cottonseed hulls. As a result of a carefully conducted experiment in calf-feeding, it has been demonstrated that a reduction of about sixty per cent in the cost of feeding young calves during the first fourteen weeks may be effected by a gradual substitution of rolled oats for whole milk after the first week when fed in conjunction with a grain ration consisting of one part each of corn meal, linseed meal and wheat bran after the fourth week. The practical bearing of these results will be appreciated when it is considered that one pound of rolled oats, costing about four and one-half cents, contains the same nutritive value as one gallon of milk, which will sell for thirty to forty cents. Some effort has been given to planning and constructing an ice-box, a milk and cream cooler and a sterilizer that would be cheap and efficient for small dairies. With each of these as devised greater efficiency has been secured at greatly reduced cost over the means and appliances ordinarily employed. The cooling investigations have brought out the fact that to a large extent the delivery of the milk may be made entirely independent of the time of milking. Milk kept cool for fifteen hours before delivery has been found to reach the consumer in better shape than milk taken

from the same cows under the same conditions and put into his hands immediately upon milking without cooling. The value of these results will be appreciated by dairymen who have had to begin milking at two to three o'clock in the morning in order to have their product come upon the market in satisfactory shape, because the milk handled in the usual way will only keep in good condition for a very few hours, especially during the summer months. By cooling to 45 degrees Fahr. and keeping the milk at this temperature, delivery may be delayed for twenty-four hours under the most trying weather conditions, thereby obviating the absolute necessity for milking earlier than a convenient hour by those who are engaged in the milk-supply business.

A study has been made of the relative efficiency in maintaining low temperatures of four different types of shipping cans for cream. Unfinished cooling and sterilizing experiments are being continued in the dairy laboratory.

DIVISION OF ENTOMOLOGY.

Much of the time of the Entomological Division during the past year has been taken up in planning and starting new lines of investigations, as the new Entomologist began work on October 1 without practically any equipment or work in progress. Studies are being made largely on the life history of the harlequin bug, cabbage webworm, cabbage aphis, corn weevil, plum curculio and peach tree borer, supplemented by experiments designed to work out more successful and practical methods for their control. Early in October the Entomologist discovered on cabbage and turnips a new species of the cabbage webworm for North Carolina, it probably having been introduced into the State during the past two years.

An insect collection, representing all the injurious forms occurring in the State, with records of date and places of occurrence, is being gradually made. During the year a Bulletin treating of about forty insects has been prepared, which gives a description, life history and remedies for the control of these insects which attack the leading truck crops grown in North Carolina.

CORN SPECIAL.

The Station, in cooperation with the Norfolk and Southern Railway, operated a Corn Special train through the Eastern portion of the State. The Special started from Raleigh on March 22 and returned on April 1. While out, visits of two hours or more were made to twenty villages and towns and talks on matters pertaining to corn growing were made. The object in running this train was to try to stimulate farmers to the production of larger yields of corn per acre by impressing upon them the importance of the adoption of

better methods of selecting seed, fertilizing, cultivating, harvesting, handling and combating the insect and disease enemies of this crop. The train consisted of two audience cars and an exhibition car, and the lectures were sometimes delivered in the audience cars, sometimes in school or court-houses, and sometimes in the open where buildings were not accessible sufficiently large to accommodate the crowd. The smallest attendance was forty, and the largest between four and five hundred, and an average of one hundred and forty-five. At four places evening meetings were held, and these were devoted to lectures on the applications of Science to Agriculture and on general agricultural and educational matters. The train was furnished and operated free by the Norfolk and Southern Railway.

In the exhibition car were carried two to four type-ears of fifty-odd varieties of corn which we have been testing comparatively in the State during six or eight years, and which the farmers have heard of but which most of them have never seen. In addition to these, seed of varieties of oats, wheat and cowpeas and samples of the leading types of soil found in the State were neatly arranged in museum jars to emphasize those salient points which it was especially desired to bring out and impress. On board were also specimens of the insects and diseases which are doing most damage to the crops and orchards of North Carolina, affected plants and seeds, and spraying mixtures and apparatus that should be used in combating them.

At each stop, as far as possible, the crops and orchards were examined and affected specimens were brought into the cars and discussed and remedies recommended. It is believed that in this way the farmers in the localities visited were impressed with the importance and practical value of the work of the Station.

BULLETINS.

Bulletins have been issued as follows:

No. 197.—Some Insect Enemies of Garden Crops, by R. I. Smith.

No. 198.—Handling and Marketing of Milk and Cream, by John Michels.

No. 199.—Feeding Experiments with Cows and Calves, by John Michels.

No. 17.—(Press Bulletin)—The Grape Black Rot, by F. L. Stevens.

The reports of the heads of the several Divisions and financial statement follow:

REPORT OF CHEMIST.

During the past year the Chemical Division has made analyses of four hundred and eighty-six samples, of which four hundred and fifty-five related to the work in investigation and thirty-one were miscellaneous.

The miscellaneous samples consisted of:

Soils	3
Marls	3
Fertilizing materials	9
Feeding stuffs	6
Lemon oil and extract	3
Drinking water	1
Solutions for standardization	6

These thirty-one miscellaneous samples involved ninety-five determinations, as follows:

Chlorine	1
Sulphuric acid	1
Total nitrogen	24
Free ammonia	1
Albuminoid ammonia	1
Total phosphoric acid	15
Soluble phosphoric acid	8
Insoluble phosphoric acid	10
Silver	1
Potash	8
Lime	5
Moisture	3
Total solids	1
Insoluble matter	4
Volatile matter	1
Ash	1
Alkalinity	4
Acidity	1
Citral	3

The miscellaneous work was for the Divisions of Administration, Agronomy, Botany, Dairy Husbandry and Poultry Husbandry of the Station.

The four hundred and eighty-five samples, relating to the work in nitrogen, involved nine hundred and seventy-three determinations, as follows:

Ammonia by the Kjeldahl and Nessler methods	54
Ammonia by the Kjeldahl method	6
Ammonia by sodium hydroxid	68
Ammonia by magnesia	274

This work on nitrogen has occupied the greater part of the time and energies of the Chemical Division and has consisted of a study of nitrogen fixation, ammonification, nitrification and denitrification in soils and in solutions, under different conditions and with different organisms and nutrients. The details of the work will be set forth more fully in bulletin form and in the report of the Botanical Division, in cooperation with which this work is done.

Among other conclusions reached, it has been found that the organisms concerned with nitrogen metabolism do not act the same in soils and in solutions and that there is no relation between the results in these two media. This shows that the use of soils themselves for this investigation as originally planned by this Division several years ago was wise.

This Division has devised a method for getting rid of organic matter in soil extracts so that the amount of nitrates may be determined colormetrically without interference from this cause. A paper embodying the results of this work is submitted herewith for publication.

This Division is very much handicapped for lack of room, and it is to be hoped that the next General Assembly will provide a Chemical Building for the Station and College work. In the meantime more space is very desirable.

The analytical work of this Division was performed by W. A. Syme mainly, and to a small extent by A. J. Wilson, both of whom have shown commendable zeal and corresponding success in their efforts.

Very respectfully,

W. A. Withers,
Chemist.

REPORT OF BIOLOGIST.

I beg to submit a report of the work of the Division under my charge for the fiscal year now closing:

INVESTIGATIONS CONCERNING APPLE DISEASES.

Work concerning apple diseases began in 1906 under the Adams fund, has been continued throughout the year.

Apple Twig Disease, which prevails in most sections of the State, has been closely studied. The fungus which causes it has been isolated and its character studied in pure culture. It proves to be a species of *Phyllosticta* or *Phoma,* which has been very destructive to fruit in Arkansas, West Virginia, and several other States. As yet the disease seems to be limited to the twigs, and has not been noted upon fruit here.

A second apple twig disease has been found in destructive abundance in many sections of the State. It proves to be a species of *Hypochnus,* which has not been recognized heretofore except in Brazil, where it was reported by Noack in 1898.

Apple Leaf Spot, which is very destructive, especially in the mountains, has been studied, and will be the subject of further investigation.

Cankers of apple and pear branches are exceedingly abundant and destructive, and scores of specimens have been received. These cankers have been studied and it has been determined that, in most instances, they are due to *Sphæropsis.* Sphæropsis canker of the apple is an old enemy, but it seems to be especially destructive here. Sphæropsis canker of the pear has not, to my knowledge, been known before. Both of these cankers, in addition to causing injury to the twig and branch, also bring about ripe rot of the fruit.

Monilia fructigena, causing rot of the apple, has been found and studied somewhat. This is the first time, to our knowledge, that this disease, which is exceedingly destructive in Europe, and which has been reported in some other parts of the United States, has been found in North Carolina.

INVESTIGATIONS CONCERNING LETTUCE SCLEROTINOSE.

Investigations of this exceedingly serious lettuce disease, begun under the Adams fund a year ago, have been continued throughout the past year. Two large cold frames for the raising of lettuce under canvas have been constructed on the Station farm, and a small crop of fall lettuce and a large crop of spring lettuce was raised for the purpose of studying the disease. Hundreds of plants were inoculated and the progress of the disease carefully noted. The fungus

was also studied in the laboratory, receiving close attention as to the manner of infection by means of spores and mycelium; as to the life history of the fungus; number of spores formed and the condition of spore formation; action of poisons upon the fungus; its growth at normal temperatures; and other points of morphological and physiological interest. Much was learned concerning the fungus and the disease. This matter will be presented for publication in bulletin form soon. The lettuce beds, now thoroughly infected with the disease, are in excellent condition to begin a study of methods of combating the disease, using to this end the knowledge which we have gained concerning it in this year's study.

OTHER PLANT DISEASES.

Cotton Anthracnose.—Many complaints have been received from various portions of the State concerning cotton anthracnose. Some attention has been given to it in the laboratory, and some tests concerning the transmission of this disease from year to year, by seed, are under way.

A New Sweet Potato Disease.—A sweet potato disease that we are calling the "soil rot," which seems not to have been described in literature before, has been repeatedly submitted to this laboratory by sweet potato growers from various sections of the State. We have found a fungus (*Fusarium*) which is constantly associated with this disease, and which seems probably to be the cause of it. Experiments are under way to determine whether this is actually so.

An Unknown Tobacco Disease was reported to us from Hillsboro. An examination of the disease was made on the ground. Numbers of plants were dead in certain regions of the field. No cause could be assigned. Material was brought to the laboratory for further study and no fungus or parasite was found associated with this disease. If this disease should prove of permanent importance, further study will be given to it.

Corn Mold.—Samples of moldy corn have been received from about fifty farmers, and in nearly every case the mold seems to be due to a species of *Diplodia*. A report of this work on corn mold will be published soon.

Bean Anthracnose.—Material for study of seed transmission of this disease, which prevails throughout the trucking section of the State, has been secured, and a study will be made of the transmission of the disease from year to year by seed, and also of the possibility of preventing such transmission.

Cucumber Mildew.—Cucumber mildew has been very destructive in several portions of the State on both cucumbers and cantaloupes. We have planted cucumbers in our lettuce beds and will conduct spraying experiments upon them this spring.

Pear Septoria.—In the neighborhood of Wilmington, pear trees suffering very seriously from some disease were found. Laboratory study showed this disease to be caused by a species of Septoria.

COLLECTION OF PLANT DISEASES AND FUNGI.

An effort has been made to enlarge the Station collection of all kinds of parasitic fungi, either on weeds, cultivated plants, or wild plants. Also to secure typical specimens of diseases of cultivated plants.

GERMINATION OF OAT SEED.

This has been a subject of rather extensive investigation. Oats were submitted to formalin at different strength, for various lengths of time, under various conditions, using different qualities and different varieties of oats. It was found that different varieties would withstand the action of formalin differently; that the seed of poor quality are killed to a much larger extent than are seed of better quality. It thus appears that the few seed lost in the formalin treatment are undesirable ones.

PLANT BREEDING FOR DISEASE RESISTANCE.

Watermelon Wilt.—The work of testing and selecting melons with the object of securing a variety resistant to the wilt, was continued this year. Ten varieties resulting from previous selections were tested on isolated plats on sick soil at Auburn. There was a very much larger percentage of resistance this year than last, more of the plats produced edible melons and there was a very much larger percentage of edible melons on the plats, than in previous years, nearly three-fourths of the melons in some plats being of high quality.

Twenty-nine selections of seed from melons of high resistance to the disease and of highly desirable quality were made for further tests next year.

Tobacco Wilt.—Several varieties of tobacco have been developed in our previous breeding work to such an extent that they will grow with high resistance upon infected soil on which none of the ordinary varieties of tobacco will grow at all. We now have five such varieties. With one only forty plants out of nine hundred and fifteen wilted; another fifteen out of three hundred and fifty-nine; another twenty-five out of three hundred and five. These strains of tobacco will be tested again this year.

STUDY OF SPORE MEASUREMENT.

A study of spore measurement has been made with the object of ascertaining the degree of variability existing among fungi when grown under different conditions with different nutriment, etc. Results of this work are about ready for publication.

SOIL BACTERIOLOGY.

Nitrification.—Work on soil bacteriology under the Adams fund has been continued. Nitrifying organisms, both the nitrate makers and the nitrite makers, have been isolated, enabling us to study them in pure culture. An improvement upon various methods of technique has been made regarding the preparation of silicate jelly. An account of this was published in the *Centralblatt fur Bakteriologie, Parasitenkunde u. Infektionskrankheiten,* Volume XXI, No. 13, 1908. Very numerous tests have been made of the nitrifying power of various soils under various conditions, and a critical study has been made of the methods of determining nitrifying power of soils, and the factors which effect the nitrifying power. The relation of temperature, aeration, degree of moisture and chemical composition of the medium to nitrification has been closely considered. Careful study has been made of the behavior of nitrifying organisms when in solution and when in soil. It has been ascertained that there is a very great difference in the behavior of these organisms in the solution and in the soil. An attempt has been made to ascertain the reason for this difference.

Ammonification.—Ammonifying organisms have been studied much as have nitrifying organisms, to ascertain what proportion of soil organisms are ammonifiers, under what conditions they ammonify most rapidly, and the behavior of these organisms in soils and in solutions.

Nitrogen Fixing Bacteria.—Some attention has been given to these organisms, particularly as to their ability to fix nitrogen in soils, as compared with their ability to fix nitrogen when in solutions.

Availability of Ammoniacal Nitrogen as Compared with that of Nitrate Nitrogen.—This fundamentally important question has been made the subject of study in pot tests and in the field. It seems very probable, from other studies, that our soils are deficient in nitrifying power. If this be so, it is very important to know whether nitrogen in the form of ammonia is fully as acceptable to the plant as nitrogen in the form of nitrate. If the nitrate be for any reason better suited to plant nutrition, it then becomes important to devise some mode of increasing the nitrifying power of our soils.

LEGUME INOCULATION EXPERIMENT.

Tests are planned and are partially under way to determine whether the root tubercle organism of burr clover is capable of producing root tubercles upon alfalfa.

PTOMAINE INVESTIGATION.

Investigations have been begun to determine under what conditions poisonous products are formed in milk, and what source of con-

tamination is most likely to produce such poisons. The work has not yet been carried to completion.

PLANT SURVEY.

This work is carried on in cooperation with the Bureau of Plant Industry. Hundreds of letters have been sent to farmers throughout the State, in order to ascertain the prevalence of certain diseases of plants, and to secure information concerning their distribution. On pages 66-82 are given the results of this work.

CORRESPONDENCE.

Numerous inquiries concerning plant diseases and other botanical questions have been received and answered. In all, about 4,000 pieces of mail matter have been sent out from this Division.

CORN TRAIN.

One member of this Division accompanied the corn train on its ten day trip to speak on "The Prevention of Plant Diseases." Approximately 3,000 farmers were in this way reached, concerning this important subject.

COMPLETED WORK.

There is now ready for publication a Bulletin on oat smut, containing the results of some six years' work on this subject. There was published, during the past year, a Press Bulletin on the Black Rot of the Grape. A technical article on the prevention of diseases of small fruits is also practically ready for publication.

I wish to acknowledge the efficient aid of J. C. Temple, Assistant in Soil Bacteriology, and J. G. Hall, Assistant in Pathology, each of whom is an exceedingly capable and well-trained man, enthusiastic and devoted to his work.

F. L. Stevens,
Biologist.

REPORT OF POULTRYMAN.

I beg to submit the following report of the work in the Poultry Division for the year ending June 30, 1908:

For the past two seasons we have been pedigree breeding from a large number of hens in an effort to improve the laying qualities of our flock. The work done in this direction shows us that it is necessary, if we are to get the best results, to have more information about our breeders than simply how many eggs they each lay during the year, and for this reason we have for the past year been keeping records of the number of eggs laid by each hen, the fertility of the eggs, chicks hatched and the number living until four weeks old. The system that we have adopted of keeping the pedigree of the chicks will also give us the age of each chick, and this data should in a few years afford valuable information as to the best hatching season for profitable egg-production.

Work has also been commenced during the year to determine if inbreeding can be practiced for a number of years without detriment to the health and vigor of the stock, if proper attention is given to these characters in selecting stock.

There is a belief quite prevalent, especially among farmers, that inbreeding is detrimental in poultry work, or for utility poultry at any rate, and that if the practice is of any value it is only in the breeding of exhibition poultry.

It is believed that if it is an advantage for one class of breeders it may be just as useful to the others if properly used, and that many breeders are losing a great deal on account of their prejudice against this practice.

In order to test this we are breeding two different strains of Barred Plymouth Rocks, keeping each line pure, and as a check crossing the two from time to time to see if there is any advantage in the introduction of new blood.

Realizing that cottonseed meal is one of the cheapest and best stock feeds obtainable, we have undertaken some experiments to determine if it can be as successfully used in poultry feeding as in feeding other kinds of stock, and if so, in what proportion and combinations it will give the best results.

Considerable work has been done in artificial incubation, special attention being given this season to the question of whether it is beneficial to disinfect the incubator before each hatch, also whether the addition of moisture helped the hatch, either from the standpoint of the number of chicks hatched or the vitality of the chicks.

Six incubators were used in this work, all of one size and make, and machines which are sold as non-moisture machines, that is ma-

chines that do not need any supplied moisture. Results varied considerably from one hatch to another, and it is thought best to continue this work another season, trying as far as possible to eliminate the conditions that we think were most largely responsible for the varying results from the same machines in different hatches.

It has been the almost universal custom to raise chicks that are hatched in incubators, in brooders with artificial heat, but during the past year considerable interest has been aroused in a method of raising the chicks without supplied heat, in what is known as a fireless brooder. If this system is a success it can readily be seen that it will mean quite a saving in the cost of raising chicks artificially, saving the cost of the kerosene and the time of an attendant in looking after the lamps. Information as to this system is at present time confined almost exclusively to the claims of the parties advertising the system, and it is our intention to try this system the coming season so that we can give information as to its use to parties who are interested and want information from a disinterested source.

Respectfully submitted,

J. S. Jeffrey,
Poultryman.

REPORT OF HORTICULTURIST.

Since no experimental work had been done by the Horticultural Division for a number of years previous to my appointment, the work has of necessity been largely of a formative nature. No line of work has been carried to completion. This Division is now confining itself to the following lines of investigation:

DOUBLE FLOWER OF THE BLACKBERRY AND DEWBERRY.

This trouble, generally known as "double flower" or "double blossom" among our dewberry and blackberry growers, gets its name from the fact that there is usually a doubling of the flower. The term "rosette" would be equally applicable because of the rosette-like growth produced from the buds in spring.

The Horticulturist began studying the trouble during the summer of 1907. It was found in several sections of the State, and in each section the blackberry industry has been practically wiped out.

Experiments at Cameron.—The trouble was such a serious one that the horticulturist at once began cooperative work on a small scale with three of the leading growers at Cameron, N. C. This was to determine the nature of the abnormality, to get the growers interested, and to get the work started, since it would require at least one year before the work could be undertaken at the Experiment Station. The experiment is being conducted as follows in each field:

Four typical adjacent rows were selected in each field. The entire growth, both old and new canes, of two rows, was entirely destroyed early in July immediately after the picking season. These plants must produce sufficient new cane growth during the remainder of the season for the following year. Only the old growth (fruiting canes) was cut out of the other two rows, leaving the young cane growth made during the spring to produce the next year's crop.

This was done to determine what influence the different methods of destroying the old growth will have on the "double flower," and second, whether it is necessary to go to the heavy expense of destroying all of the cane growth, and then fertilizing heavily to produce the second growth of new canes the same season. The plants have been carefully studied since the work was started and valuable data have been obtained. Photographic records are being made of the development of the normal and abnormal buds and growth. While valuable data have already been obtained, the most important data during this season will be obtained during the fall months. Furthermore, it will require further study and experimentation before conclusive statements can be made regarding the cause and best method of controlling the trouble.

Experiments at Station Farm.—Extensive experiments with "double flower" are now being conducted on the Station farm. Six

plots of Wilson blackberry and six plots of Lucretia dewberry, each plot consisting of three rows, are being devoted to this work. These plots were planted during January of the present year. These particular varieties were selected because they have been the most important, commercially, in the State and are badly affected. It will require one season to get the plants well established before any real experimental work can be undertaken. Each plot will then be treated differently in the way of pruning and destroying the old and young canes to see what effect it will have on the "double flower."

Aside from this, we are testing twenty-two other varieties of blackberries and fourteen of dewberries to determine what varieties are affected.

SELF-STERILITY OF DEWBERRIES AND BLACKBERRIES.

Many of our varieties of dewberries and blackberries give unsatisfactory results when planted by themselves. This appears to be due in many cases to self-sterility.

We are now testing fifteen varieties of dewberries and twenty-three of blackberries to determine to what extent they are self-sterile; the cause of this self-sterility, and the varieties that will be the best to use for the pollination of self-sterile varieties.

Since these plants were just planted during the past winter, no data can be obtained until they come into bearing next year.

CONTROLLING ANTHRACNOSE BY CULTURAL MEANS.

The Horticulturist is now carrying on cooperative work with five of the leading dewberry growers to determine the best cultural means of controlling this disease. It is the most serious disease with which dewberry growers have to contend at the present time.

The present methods of controlling the disease are very costly. I believe that this cost can be considerably reduced by improving and modifying the present cultural methods.

These experiments are to determine how often the canes should be cut off; the best depth to cut them, and the best tools for this purpose.

The work was started last summer and accurate records have been kept of the rate and character of new growth. This year records will be kept of the amount of fruit yielded by each plot.

MISCELLANEOUS WORK.

The Division is giving considerable study to several of our leading fruits. Photographs are being made and notes taken on the various methods of propagation, planting, cultivation, and marketing of the more important fruits. The Division has made a fairly complete survey of the dewberry industry of the State, including localities, names and addresses of growers, and acreage. A similar survey of other leading fruits is now well under way.

Respectfully submitted,

F. C. Reimer,
Horticulturist.

REPORT OF ANIMAL HUSBANDMAN.

I beg to submit the following report of the operations of this Division for the year just closed:

It will be necessary to say at the outset that the brief report following is simply a general status of the work now in progress by this Division. No line of work has been fully completed during the past year, owing to the fact that it was necessary to provide entirely new equipment on the Station farm.

The first line of work undertaken was a determination of the amount of fermented cottonseed meal which could be fed safely in conjunction with corn to young and growing hogs; to determine the economy of gain; and the quality of the product when compared with corn alone, and corn and linseed meal.

The length of the feeding period was six months. The check lot of pigs fed on corn remained in an unthrifty condition all during the experiment. The two lots of pigs fed on corn and cottonseed meal in varying proportions made larger gains as the amount of cottonseed meal was increased. This was true, however, only during the first period of three months. The lot which made the largest gain received the most cottonseed meal, though none of the pigs were fed more than .62 pound per day. The gains made were clearly in favor of the ration composed of four parts of corn and one part of cottonseed meal. The limit of profitable feeding was three months or thereabouts. During the last three months of the feeding period the gains were materially decreased with all pigs fed cottonseed meal, which would seem to indicate that this material should not be fed longer than seventy-five to ninety days. If fed to hogs, great care should be taken to measure or weigh the amount fed each time, and discontinue feeding after the time stated. While it is possible that the feeding period could be lengthened, it would not seem to be a safe venture for the farmer to make.

A second line of work was undertaken to determine the relation between feeding hogs in dry lots and on forage crops. The ration for each lot consisted of three parts of corn and one part of fermented cottonseed meal. With three lots, this ration was fed in conjunction with green crops; with the fourth lot, the corn and cottonseed meal were fed alone in the same proportion in a dry lot. This experiment is now nearly completed, and bids fair to give valuable data in favor of the green crops, which can be produced so abundantly by North Carolina farmers. The first grazing crop furnished was fall rye, after which oats and Canada peas; oats and rape were given as a second series in the succession. For the third series of forage crops, cowpeas and corn, cowpeas and sorghum, sweet potatoes and peanuts were fed. These crops all made rapid growth and furnished feed for the greater part of the summer and fall months.

This is one line of work which the Station expects to thoroughly

investigate, as swine raising is one of the paying lines of work for the farmers in this State. The pigs in this experiment are all thrifty and will be ready for market by the latter part of December, after which the results of the experiment will be reported in detail.

The third line of work undertaken was the feeding of cottonseed meal to horses and mules to determine:

1. The possibility of using such a supplementary feed with corn.
2. The economy of the ration.
3. The amounts and condition in which it could be most satisfactorily fed.
4. The effect on the condition of the animal.

The work mules of the Station are being used in this experiment, and each mule will receive one of the rations fed each of the other mules during the experiment.

The preliminary period of the experiment, lasting from April 6 to May 20, proved conclusively that the meal was relished by the mules in quantities as large as one pound, and in some cases one and one-half pounds per day. The meal was mixed with ear-corn for two mules, and with corn and cob-meal for three mules during the first part of the final feeding period. The final ration which is being fed at the present time, is composed of ear-corn and cottonseed meal, the meal fed ranging from three-fourths of one pound to two and one-fourth pounds per day.

The above experiment is to be run one year exclusive of the preliminary period. The ration will be reversed at the end of every two months to eliminate individuality. During the first part of the experiment the same amount of meal was substituted for the corn that was taken out of the ration. At present, however, one pound of cottonseed meal is being substituted for as much as two pounds of corn, to determine the efficiency of the cottonseed meal in furnishing protein, in replacing the corn and balancing the ration.

Most farmers are feeding an all-corn ration, which is very expensive and undesirable, to say the least. The purpose of this experiment has been to work out a cheaper, practical and more efficient ration.

In addition to the above work, there has been considerable improvement made at the Station farm in the way of buildings and lots. A number of farrowing pens have been built, feeding floors, pens and hog pastures.

The Station has also purchased several high grade Poland China brood sows and a pure bred boar, which are to be used for raising hogs of uniform type for future experimental work.

Considerable correspondence has been carried on, this being mostly in reference to breeds of live stock best adapted to the conditions of the State; questions in regard to breeding, feeding and management of live stock; and the laying out lots for pasture purposes.

R. S. Curtis,
Animal Husbandman.

REPORT OF DAIRY HUSBANDMAN.

The data obtained on the relationship of cold to the keeping quality of milk prove conclusively that it is feasible for dairymen to deliver their morning's milk in the afternoon and the night's milk the following morning, thus making the milking independent of delivery. Indeed they prove that sweet milk may be furnished by making only one delivery a day. The data, therefore, point the way to saving a great deal of labor as well as much unnecessary drudgery.

The feeding experiments showing that rolled oats may be gradually substituted for milk in calf rearing, are of far-reaching importance in that the reduced cost resulting from such substitution will undoubtedly be a strong factor in inducing dairymen to raise enough calves to build up and replenish their herds.

In the stover and hull experiments conducted by this Division, the fact is brought out that dairymen will save thousands of dollars annually by raising and feeding corn stover instead of buying and feeding cottonseed hulls.

In another experiment, it was demonstrated that dried brewers' grains have the same feeding value as corn meal when both are used to supplement a grain ration consisting of one-half cottonseed meal and one-quarter corn meal. Since the dried brewers' grains can usually be purchased at a much lower price than corn meal, the economy of using them is evident.

The original plans presented for the construction of cheap ice boxes and sterilizers will, if adopted generally, save thousands of dollars to our dairymen, besides resulting in more efficient cooling and sterilizing than would be possible without them.

The Division has also worked out a new method for making cottage cheese, which is especially adapted for making this cheese on a commercial scale.

Cottage cheese has been made for centuries, but this is the first time, so far as known to the writer, that any successful effort has been made to place the making of this cheese upon a commercial and scientific basis. The method of manufacture, as well as the method of marketing, as worked out by us, insures absolute uniformity of product, and makes it possible to manufacture cottage cheese on as large scale as is done with many other kinds of cheese.

This new method opens the way for an extensive and profitable use of skim milk.

Respectfully submitted,

John Michels,
Dairy Husbandman.

REPORT OF ENTOMOLOGIST.

When I came to the Station on the first of last October, I found the Entomological Division practically without laboratory, library and office equipment. Some little time was required to get things in shape before any investigational work could be taken up. The insect collection was found to be small, poorly arranged and contained few of the more common species. My time, therefore, for the past nine months, has been devoted largely to making insect collections—both by collecting and by breeding—to attending to correspondence, and to getting under way new lines of investigation.

PUBLICATIONS.

A Bulletin, entitled "Insects Injurious to Garden Crops," which contains sixty-four pages, has been prepared. This was written with especial reference to the needs of gardeners, truckers and farmers in North Carolina.

INVESTIGATIONS.

Life history studies, and in some instances experiments with remedial measures, have been conducted with insects as follows:

Harlequin Bug (*Murgantia histrionica*).—Commencing when the bugs first appeared this spring, careful observations and notes were made to determine the following points:

(1) Egg laying record; (2) period of incubation of eggs; (3) length of life cycle; (4) number of generations; (5) parasitism of eggs and nymphs; and (6) general habits.

Various direct remedies have been tested and the kerosene emulsion treatment of fifteen per cent strength has proved quite effective against young and half-grown bugs, while it also prevents some of the eggs from hatching. The egg-laying record of the hibernating brood has been secured, one female laying one hundred and seventy-nine eggs between April 7 and June 9. Other individuals under observation laid from ninety-six to one hundred and twenty eggs during a shorter period. Many interesting and important facts about terrapin bugs have been noted, but this line of investigation is yet in progress.

Cabbage Web-worm (*Hellula undalis*).—Plans were made this spring to study the life history of this insect, which was first discovered in North Carolina by the writer during the past October. Up to June 30 no web-worms have put in their appearance, but it is expected they will be present certainly by late summer or early fall.

Cabbage Aphis (*Aphis brassicæ*).—Gratifying results have been secured from the use of a spray of common soap solution as a remedy against the cabbage aphis. During the year tests have been made

both on the College and Central Hospital farms, using various soap solutions of different concentrations in comparison with ten and fifteen per cent kerosene emulsion and tobacco decoctions, with the results indicating the superiority of common soap solution, both in efficiency and economy.

Plum Curculio (*Conotrachelus nenuphar*).—This insect was made the subject of a life history study during the spring and the length of egg, larva and pupa stages were determined for North Carolina conditions. A common species of parasite (*Sigalphus curculionis*) was reared in considerable numbers from the curculio larvæ. Observations on the egg-laying and feeding habits were made and recorded. The scope of this experiment is also to be increased, and it is to be continued during the coming year.

Fumigation Against Corn Weevils.—Because of numerous complaints of poor results coming from the use of carbon bisulphid as a remedy against corn weevils, the writer has undertaken to find some other substance or substances that will be cheap and effective. A number of tests were made during February and March, but the results, while encouraging, indicate that much further work of an enlarged nature should be carried on before attempting to draw definite conclusions. Extended work is planned to be taken up in a vigorous manner during the coming year.

Respectfully submitted,

R. I. Smith,
Entomologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATIONS, 1907-1908.

DR.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1908, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	9,000.00

CR.

	Hatch Fund.	*Adams Fund.*
By Salaries	$6,945.83	$6,780.00
Labor	2,624.90	508.57
Publications	938.54	.....
Postage and stationery	434.98	.....
Freight and express	258.59	.....
Heat, light, water and power	58.79	.....
Chemical supplies	36.81	406.94
Seeds, plants and sundry supplies	445.97	367.91
Fertilizers	218.10	308.77
Feeding stuffs	733.04	.....
Library	109.00	143.29
Tools, implements and machinery	350.86	.....
Furniture and fixtures	566.30	.....
Scientific apparatus	1.23	162.05
Live stock	457.00	200.00
Traveling expenses	467.05	122.47
Contingent expenses	15.00	.....
Buildings and land	338.01	.....
Total	$15,000.00	$9,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1908; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $24,000, and the corresponding disbursements $24,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed)

J. T. ELLINGTON,
O. L. CLARK,
T. T. BALLENGER,
R. H. RICKS,
Auditors.

(Seal.)

Attest: A. F. BOWEN, *Custodian.*

SCIENTIFIC PAPERS.

EXPERIMENTS UPON THE EFFECT OF FORMALIN UPON THE GERMINATION OF OATS.

By F. L. STEVENS.

Many different strengths of formalin are or have been at various times recommended for the prevention of oat smut; also many different modes of application and different lengths of exposure to the formalin fumes.

The two factors which must control in the selection of the strength to be employed, and the time and the mode of application, are the fatality to the smut spores and the effect upon the germination of the grain.

While the strength of one ounce to one gallon of water is employed by many with success, it occasionally results in a loss of the crop, due to its killing the seed; therefore this strength is to be regarded as within the danger limit, and is not to be recommended.

In order to ascertain whether one ounce to two gallons of water is dangerous to seed, tests were made during May, 1905, with one hundred seeds, employing three different strengths of formalin, as indicated in the following table, and with the fertilizer in one case put in the drill, in the other well mixed with the soil, and in the third using no fertilizer:

TABLE I.—SHOWING THE EFFECT UPON GERMINATION OF FORMALIN SOLUTIONS OF DIFFERENT CONCENTRATIONS.

	One Ounce Formalin to One Gallon.	One Ounce Formalin to Two Gallons.	One Ounce Formalin to Three Gallons.	Average.	No Formalin.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
No fertilizer	38.5	80.5	37.5	52.2	88 0
With fertilizer mixed with soil	63.	60.5	67.5	63.7	
With fertilizer unmixed with soil	68.5	57.5	53.5	59.8	100.0
Average	56.7	66.2	52.8	58.7	69.0

The results are so irregular and discordant that no conclusion seems justified unless it be that in such tests a much larger number of seeds should be used to give more reliable averages. The test was therefore modified and repeated on a larger scale in June, 1905. In each instance one pint of seed was treated with the formalin solu-

tion at the rate of one gallon of solution to one bushel of seed. After treatment two hundred seeds were taken for the germination test, with the following results:

TABLE II.—SHOWING EFFECT UPON GERMINATION OF FORMALIN SOLUTIONS OF DIFFERENT CONCENTRATIONS.

	One Ounce Formalin to One-half Gallon.	One Ounce Formalin to One Gallon.	One Ounce Formalin to Two Gallons.	One Ounce Formalin to Three Gallons.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Cloth-covered 12 hours after treatment then planted immediately	25	95	97	93
Planted immediately after treatment	47	99	88	89
Dried 48 hours after treatment before planting	43	96	98	94
Cloth-covered 12 hours then dried with lime before planting	35	94	94	96
Average	37	96	94	93

It comes out clearly from this experiment that the strongest solution injures germination seriously, though no injury is apparent from the treatment by the other solutions under any of these conditions. There is even an indication of increased germination with the increase of the formalin, as shown by the averages, 93, 94 and 96 per cent. Whether such stimulation is a fact or whether the differences shown in the table are due to accidental variation in the seeds it is impossible to say. There is no significant difference resulting from the modes of treatment with any of the strengths unless it be with the strongest solution, which showed greatest fatality when covered 12 hours and when planted immediately. This is to be expected, since both of these modes of treatment tend to retain the formalin fumes in contact with the seed for a longer time than do the other treatments.

The solution of one ounce of formalin to one gallon of water did no appreciable injury to these seeds with any of the modes of treatment followed. In field practice, however, this solution and even weaker solutions are known under some conditions to deplete the stand. It seemed, therefore, that some other factor must at times enter into the question; that probably there is a difference between different varieties of oats or between oats of the same variety under different conditions. A more extensive experiment was therefore planned to test the following points:

Do different varieties of oats offer different degrees of resistance to formalin? What percentage of the seed is killed by formalin of the strengths usually employed? Does formalin have any stimulating effect upon germination? Are seeds of inferior quality more

susceptible than those of medium or excellent quality? Does the fatality increase with the increase of the time of application? While many tests have been made bearing upon these points, they have usually been made with one or two factors only in mind, and the results are neither concordant nor conclusive.[1]

A series of crucial experiments was planned with the hope of gaining conclusive answers to these questions.[2]

In all cases 1,000 seeds of average quality were taken and treated for twelve hours. They were treated with formalin of the strength indicated, employing 1 cc. of the solution to 9.3 cc. of seeds, this being equivalent to the usual practice of using one gallon of liquid to one bushel of seed. The seed, after being thoroughly wetted by the solution, were placed in glass capsules, of suitable size, to prevent loss of formalin by evaporation. Great care was taken to have the lots exactly alike, except as regards the factor under observation. After treatment the seeds were planted in flats in clean sifted sand in rows one-half an inch apart, with the seeds evenly distributed in the rows. In this manner, it was possible to account for every seed. The final record of germination was taken two weeks after planting, since experience showed that all viable seeds germinated in that time.

All seeds designated as of average quality were gotten by discarding from a clean commercial sample of considerable size, all foreign seeds and empty chaff, but retaining all actual oat seeds, each of which, in case of any possible doubt, was inspected as to its integrity. This sample was thoroughly mixed and the 1,000 seeds for the test were taken absolutely without selection by always taking the seed lying nearest at hand, be it large or small. The strengths most used in practice, .26 per cent, .39 per cent, and .78 per cent of formalin, or as more commonly designated, one ounce to three gallons, one ounce to two gallons, and one ounce to one gallon, were employed; also a weaker solution, one ounce to four gallons (.2 per cent formalin). The first of these is mostly used, the second often, and the third rarely.

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[1] A summary of much that has been done is presented by G. Kock Uber die Bedeutung des Formaldehyds als, Pflanzenschutzmittel U. S. V. Zeit. f. Land—Versuchswesen, Oest—. Jahr IX 1906 811.

[2] In carrying out these tests I am indebted to the efficient assistance of F. H. Brown.

INFLUENCE OF DIFFERENT STRENGTHS UPON WHITE SPRING, RED RUST PROOF, VIRGINIA WINTER GRAY, APPLER, BURT, BLACK SPRING OAT OF AVERAGE QUALITY TREATED TWELVE HOURS.

TABLE III.—TEST OF THE WHITE SPRING OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
11	Control	998	99.8	
14	One ounce to four gallons [1]	996	99.6	—.2
15	One ounce to three gallons [2]	993	99.3	—.5
13	One ounce to two gallons [3]	985	98.5	—1.3
12	One ounce to one gallon [4]	941	94.1	—5.7

[1] .2 per cent formalin, .08 per cent formaldehyde.
[2] .26 per cent formalin, .104 per cent formaldehyde.
[3] .39 per cent formalin, .156 per cent formaldehyde.
[4] .78 per cent formalin, .312 per cent formaldehyde.

TABLE IV.—TEST OF RED RUST PROOF OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
16	Control	989	98.9	
17	One ounce to four gallons	984	98.4	—.5
20	One ounce to three gallons	984	98.4	—.5
19	One ounce to two gallons	973	97.3	—1.6
18	One ounce to one gallon	925	92.5	—6.4

TABLE V.—TEST OF VIRGINIA GRAY OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
30	Control	895	89.5	
29	One ounce to four gallons	883	88.3	—.2
28	One ounce to three gallons	855	85.5	—.4
27	One ounce to two gallons	821	82.1	—7.4
26	One ounce to one gallon	790	79.0	—10.5

TABLE VI.—TEST OF APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
10	Control	966	96.6	
8	One ounce to four gallons	977	97.7	+1.1
9	One ounce to three gallons	958	95.8	—.8
7	One ounce to two gallons	933	93.3	—3.3
6	One ounce to one gallon	912	91.2	—5.4

TABLE VII.—TEST OF BURT OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
1	Control	903	90.3	
2	One ounce to four gallons	922	92.2	+1.9
3	One ounce to three gallons	930	93.0	+2.7
4	One ounce to two gallons	901	90.1	—.2
5	One ounce to one gallon	730	73.0	—17.3

TABLE VIII.—TEST OF THE BLACK SPRING OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Number Germinated.	Per Cent Germinated.	Per Cent ± Due to Treatment.
25	Control	934	93.4	
24	One ounce to four gallons	959	95.9	+2.5
23	One ounce to three gallons	949	94.9	+1.5
22	One ounce to two gallons	903	90.3	—3.1
21	One ounce to one gallon	911	91.1	—2.3

It will be noted that the White Spring, Red Rust Proof and Virginia Gray oats give perfectly consistent results, showing increasing fatality with an increase in the strength of the solution employed, the loss ranging from .2 to 5.7 per cent with the White Spring oat and from .2 to 10.5 per cent with the Virginia Gray oat.

The Appler, Burt and Black Spring oats show with the weaker of the two weakest strengths slight evidences of stimulation and an increased germination over that obtained without treatment, this varying from 1.1 per cent with the Appler to 2.5 per cent with the Black Spring oat.

Increase in fatality with increase in strength is shown with the two stronger solutions in Tables VI and VII.

The Burt oat with a loss of 17.3 per cent in germinating power, being the one when the strongest solution is considered, showing greater susceptibility than any other tested.

In Table VIII the Black Spring oat presents some inconsistencies, notwithstanding the large number of seeds used and the carefulness of the test. These may be explained, however, by the very high resistance of this oat to all strengths of solutions, thus reducing the total of fatalities to such a small number as to unduly magnify error from accidents. The high resistance offered by this oat is probably attributable to its smooth, shiny, black, hard glumes of extraordinary thickness.

It may be concluded from this series that formalin of the strength of one ounce to four gallons or one ounce to three gallons of water may be used without detriment to germination of these varieties, but

that greater strength will appreciably injure the germinating power of some of them, and that the stimulating effect, if any, is insignificant.

TEST OF DIFFERENT TIME OF EXPOSURE TO FOMALIN AND OF THE USE OF LIME.

TABLE IX.—APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Time Treated.	Number Germinated.	Per Cent Germinated.
10	Control		966	96.6
49	One ounce to one gallon	2—10[1]	955	95.5
31	One ounce to one gallon	2 hours	934	93.4
41	One ounce to one gallon	6 "	911	91.1
6	One ounce to one gallon	12 "	912	91.2
35	One ounce to one gallon	24 "	893	89.3

[1] Formalin two hours, lime ten hours.

Table IX indicates a gradual increase in fatality with increase of the time of application, and shows slightly beneficial effect from the use of lime. Comparison of Tables IX and XI brings out the fact that the one ounce to one gallon solution may be used for two hours with greater safety than the one ounce to two gallon solution for twelve hours, and that with lime the one ounce to one gallon solution for two hours is no more injurious than the one ounce to four gallons solution for twelve hours. While no experimental evidence is at hand regarding the resistance offered by the smut spores to these solutions of different strengths for different times, it is probable that owing to the minuteness of the spores the strong solutions for the short time would be more often fatal to them than would a weaker solution for a longer time. It is probable, therefore, that in practice it will be found best to increase the strength of the solution and to use lime, rather than to increase the time.

EFFECT OF QUALITY OF SEED ON RESISTANCE TO FORMALIN.

TABLE X.—APPLER OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Quality of Seed.	Number Germinated.	Per Cent Germinated.	Per Cent Loss Due to Treatment.
10	Control	Average	966	96.6	5.4
6	One ounce to one gallon	Average	912	91.2	
45	Control	Good	991	99.1	3.7
46	One ounce to one gallon	Good	954	95.4	
43	Control	Medium	976	97.6	4.6
47	One ounce to one gallon	Medium	920	92.0	
44	Control	Poor	937	93.7	15.7
48	One ounce to one gallon	Poor	780	78.0	

TABLE XI.—VIRGINIA GRAY OAT, 1,000 SEEDS.

Flat No.	Strength of Solution.	Quality of Seed.	Number Germinated.	Per Cent Germinated.	Per Cent Loss Due to Treatment.
30	Control	Average	895	89.5	10.5
26	One ounce to one gallon	Average	790	79.0	
36	Control	Good	924	92.4	9.8
32	One ounce to one gallon	Good	826	82.6	
37	Control	Medium	909	90.9	10.8
33	One ounce to one gallon	Medium	801	80.1	
38	Control	Poor	859	85.9	20.
34	One ounce to one gallon	Poor	659	65.9	

Seeds such as were used in the preceding tests were carefully graded into three classes, each seed being examined individually. The largest, plumpest grains were designated as "good," the next lower class as "medium," and the smaller shrunken ones as "poor." Especial care was taken that no empty glumes, but only actual seeds, be included in this last class. With the Appler oat, Table X, it is seen that in the controls the seeds germinated according to quality, 99.1, 97.6, 93.7 per cent respectively, and that when treated with formalin, one ounce to one gallon, the loss of germinating power was little with the good seeds, a trifle more with the medium seeds, but very great with the poor seeds. The average has little or no significance, since no record was kept of the percentage of seed of each quality in the average sample.

With the Virginia Gray Oat, Table XI, less concordant results were secured. The main fact, however, comes out clearly that there is much greater fatality from treatment among the poor than among the better seed.

The fact brought out in these two last tables is very significant, in that it shows that even the slight diminution in germinating power, resulting from the formalin treatment of oats, is of benefit in that it is in effect a form of seed selection resulting in a partial elimination of the poorest seed, to the betterment of the sowing. It is probably to this fact, in part at least, that we may attribute the beneficial effects of the formalin treatment, so frequently noted, even when no smut appears in control plats.

In view of these facts, it may be desirable in practice to use the strongest solution employed in these experiments, or even stronger, as a means of culling out the poor seed, to then test the germinating power in order to ascertain the loss of live seed, and to regulate accordingly the amount of seed to use per acre for sowing. Mechanical separation might, however, attain more economically the same end.

A STUDY OF CORN MOLD.

By F. L. STEVENS and J. G. HALL.

The disease of corn known throughout the State as "mold," "mildew," "rot," "souring," attracted particular attention in 1906, and study of the disease was begun at that time.

The disease affects the ear, manifesting itself as a whitish growth of mold over the surface of the grains, sometimes affecting the whole ear and at other times portions only of it. The amount of fungus visible upon the superficial parts of the grain is not large, but upon breaking open the ear, it is found that the spaces between the bases of the kernels are often densely packed with masses of pure white mycelium.

Externally, no signs of fruiting bodies of any kind are apparent, but close examination at the point of attachment of the grains to the cob, in many instances, reveals the presence of exceedingly minute black specks, which under the microscope prove to be the fruiting organs (pycnidia) of the fungus.

Numerous mail inquiries have been received concerning this disease, and in response to letters, a large number of specimens, representing many different sections of the State, were received and examined. While other fungi were occasionally present, in nearly every instance the symptoms given above were predominant, and the fungus with the white mycelium and the black pycnidia was the only one that was noticed in constant association with the disease.

The pycnidia, upon examination under a microscope, were seen to be filled with rather long, slender, smoky, usually two-celled, occasionally three-celled, spores. These spores were slightly thicker at one end than at the other, and were darker in color at the thicker end than at the narrow end.

This fungus was readily isolated in culture by means of agar plates, and it has been under cultivation in the laboratory for nearly two years. It grows rapidly, producing abundant loose, floccose, aerial mycelium, and a sparse sprinkling of the characteristic pycnidia with its characteristic spores.

While longer in proportion to the thickness than is usual in the genus *Diplodia,* this fungus must be regarded as a *Diplodia;* in its relationship, however, verging toward the genera *Septoria* and *Hendersonia,* particularly toward the dark spored, short-spored septoria, such as *Septoria piricola* Desm., which grows upon the pear.

Three species of *Diplodia* have been described upon *Zea:* 1, D. *Maydis* (Berk.) Sacc. Syll. Fung. III 373; 2, D. *Frumenti* E. & E. Syll. Fung. X 292; 3, D. *Macrospora* Earle Syll. Fung. XIV 939.

These were originally described as growing upon stems and probably were saprophytic.

The species which we mention above agrees well with the description of *Diplodia Macrospora* Earle, and is without question to be regarded as *Diplodia Macrospora,* although that species has not heretofore been reported as occurring upon the ears of corn.

A second species of *Diplodia* was also found in some instances on the molding ears, evidently as a cause of the mold. This species, while to the naked eye showing no difference from *Diplodia Macrospora* as to its mycelium or pycnidia, was markedly different in shape and size of its spores, which were regularly linear-oval, evenly colored throughout and much shorter than the spores of the *Diplodia Macrospora.* This latter species agrees completely with the description of the *Diplodia Maydis* and is to be regarded as that species.

The latter species has recently been the subject of investigation in Illinois,[1] and was also reported upon at the last meeting of the American Association for the Advancement of Science.[2]

It is estimated that in 1906, the year in which there was the greatest amount of dry rot, so far as any records have been made, the loss was 4.5 per cent of the entire crop in Illinois. This represents a loss of over 15,000,000 bushels, having a value of more than $5,000,000. The loss in 1907 was less than 2 per cent of the crop or about $2,000,000.

In order to glean from the farmers as many facts as possible concerning this disease, several hundred letters were sent out to leading corn growers throughout the State, asking the following questions:

1. Under what conditions of weather does it do most damage, during wet seasons or dry seasons?
2. Is it most damaging in corn standing alone on the stalk or in corn which is put up in the shock?
3. Does it appear before the corn is husked or after?
4. If it shows before husking, does it continue to develop after husking?
5. Is there any particular variety which is more susceptible than other varieties?
6. Does the time of ripening of corn affect the rotting?
7. Estimate the amount of damage as follows:

a. Dollars per acre.
b. Per cent of crop.
c. Damage in your county.

In response to these letters we select for analysis twenty-four replies, representing the twenty-three separate counties, Jackson, Mitchell, Ashe, Madison, Caswell, Halifax, Henderson, Pasquotank, Gas-

[1] Ill. Agricultural Experiment Station Circular 117.
[2] Science N. S. XVII, No. 684, p. 212. Dry Rot of Corn and its Causes. James T. Barrett.

ton, Stokes, Sampson, Burke, Forsyth, Northampton, Yancey, Davie, Wilson, Watauga, Buncombe, Macon, Chatham, Catawba and Alamance. In ten instances, these replies were accompanied by samples of diseased corn, which proved to be unquestionably the disease under consideration. While no certainty exists that the other fourteen replies relate to this disease, it is most highly probable that they do, since the disease was carefully described, since there appears to be no hesitation on the part of the farmer as to his recognition of it, and since in the ten instances where samples were submitted, no error was noticed.

As to the first question: there was an unanimity of opinion that the disease was worse in wet seasons than in dry ones. In one instance, the reply was that it was that it was worse in warm, wet weather.

As to the effect of shocking: three replies stated that there was no difference whether the corn was in shock or still standing, six replied that the disease was worse in the shock, and six replied that the disease was worse when it was not in shock, so that in all probability the disease is independent of this condition.

Regarding question number three: fifteen stated that the disease appears before the corn is shucked, while only two stated that the disease comes upon the corn after shucking. One stated that it continues to develop after shucking, eighteen state that it does not.

As to specially susceptible varieties: eleven replies were to the effect that some varieties were more subject to the disease than others. Three replies stated that there was no difference in susceptibility in the varieties. Among the varieties named as being more susceptible than others were the following:

Any early varieties, Iowa Silver Mine, Boone County White, Hickory King, Any red variety, Large Cob, Dent, Strawberry Corn, Sugar Corn, Soft Varieties, Yellow, Large Cob, Large Kernel.

The amount of damage was placed at from 10 to 50 to 75 per cent of the value of the crop. Estimates as to dollars per acre and the damage per county were so unsatisfactory as to be undeserving of analysis. It is certain, however, that the disease causes, in the aggregate, a very large loss in this State. Both species of *Diplodia* causing this mold are known to live and flourish upon corn stalks, and it is not to be doubted that the fungus multiplies on old stalks, making there enormous quantities of spores, which, spread by the wind, cause disease to the following crop. It is therefore very important to plow under, so far as is possible, all old stalks, leaves and shucks, to thus diminish the amount of infected material.

I. STUDIES IN SOIL BACTERIOLOGY.[1]

NITRIFICATION IN SOILS AND IN SOLUTIONS.

By F. L. STEVENS and W. A. WITHERS
Assisted by J. C. TEMPLE and W. A. SYME.

Following the lead of Robert Koch in 1881, in the utilization of his gelatine plate method for enumeration of the bacterial flora of various soils, came a vast number of researches directed toward a determination of the numbers of bacteria in soils from various sources, depths, conditions, etc., and much valuable information was gained as to the relative numbers of organisms obtaining in soils under different conditions. But it came to be recognized after a few years that the method of enumeration of bacterial floras by plate counts falls far short of furnishing the needed data for a proper understanding of the functions of bacteria in soils.

Attention was then directed toward methods, not to determine the *number of bacteria* in soils, but to determine the abundance or efficiency of the particular kinds of organisms that are known to be either beneficial or injurious to agricultural soils. This problem was essayed in two different ways, by Remy in 1902,[2] and Hiltner and Störmer in 1903.[3]

The method of Remy consists in using as an inoculum, weighed amounts, usually one to ten grams, of the soil under investigation, and with this inoculating sterile solutions of various composition to ascertain the chemical changes effected in the solutions by the bacteria introduced with the inoculum. In this way, for example, a 1 per cent peptone solution is inoculated, and the amount of ammonia found at the end of a given number of days is taken as an indication of the ammonifying power of the soil. Similarly, solutions containing ammoniacal compounds are employed to gain an index of the nitrifying power, and Giltay's solution is used to measure the denitifying power.

The method of Hiltner and Störmer consists in using solutions similar to those employed in Remy's method, but making in each analysis a series of inoculations with the inoculum varying from 1000 milligrams to 0.001 milligram of soil. Since, in some instances, the dilution used fails to cause reaction because the quantity of inoculum is so small as to contain none of the specific organisms

[1] The facts set forth in this article were presented in substantially this same form at the seventh annual meeting of the North Carolina Academy of Science May 2, 1908. See Science 27 pg. 988. This article also appears in the current volume of the Centralblatt für Bakteriologie II ab.

[2] Centr. Bakt. 2 Abt. 8 (1908) pp. 657-699, 728-761.

[3] Studien uber die Bakterienflora des Ackerbodens, Berlin, (1903).

in question, while in other instances there is reaction, indicating the presence of the organism, some conclusions are permissible as to the number of bacteria present of the particular kind in question in the inoculum used.

The methods of Remy and of Hiltner and Störmer and modifications of these, have been used in numerous investigations in soil bacteriology, and much knowledge has been gained as to the abilities of the bacteria of the soil to effect changes of particular kinds in the solutions employed and under the conditions of the tests.

The use of soil itself as a culture medium in which to study the activities of bacteria under conditions of bacteriological control seems to have been singularly neglected, and when employed, has been used only for special purposes, e. g., Coleman[1] and Bazarewski,[2] who employed soil in physiological studies of nitrifying organisms, and by Wimmer[3] and Hoffman.[4]

The object of soil bacteriology is to picture clearly the kinds and intensities of bacterial activity in the soil in order that the effects of cultural methods, fertilizers, crops, etc., upon the bacterial flora and its efficiency may be known, to the end that defects may be recognized and corrective measures employed.

That the methods of Remy, of Hiltner and Störmer and of their followers come much nearer to this ideal than mere colony enumeration, can not be doubted, but that either of these methods very closely approximates actual occurrences in the soil itself is questionable. Conditions of bacterial life in solution and in soil may be, indeed they certainly are, fundamentally different, and the most that can be said with assurance, when isolated species or natural or artificial composites of species, are inoculated into solutions of known composition and produce certain chemical changes, is that the organisms present bring about the changes noted under the conditions of the test, *i. e.,* dealing with solutions of the artificial nature of those that are employed.

By such tests it has been noted that certain species of bacteria and certain live soils when placed in solution bring about nitrification, ammonification, denitrification, etc., with certain degrees of intensity. It by no means follows of necessity that the same organisms when in soils cause the same chemical changes, or if so, with the same intensities.

To picture adequately the functioning of soil bacteria, methods must be used which show as nearly as possible the effects as they are actually produced by bacteria in soils. To assume that bacterial

[1] Untersuchungen ueber Nitrifikation Cent f. Bak. 2 abt. 20, 401, (1908).
[2] Beitrage zur Kenntnis der Nitrifikation und Denitrifikation im Boden 1906. Diss. Göttingen.
[3] Zeit. f. Hyg. 48, 160 (1904).
[4] Relation of Soil Bacteria to Nitrogenous Decomposition, 23rd Rept. Wis. Agr. Exp. St. (1906) 120.

changes produced in a solution represent the changes that would be caused by the same bacteria in a soil, is to base upon the hypothesis that the action of a given species of bacteria in a solution is the same in kind, and approximately the same in degree as is the action of the same species when in a soil.

Both upon *a priori* grounds and as the result of numerous observations during the past few years, we were led to doubt the validity of this hypothesis.[1] A series of experiments was therefore instituted to test the question: Do soil bacteria act in solutions the same as they do in soils? The results of these experiments, with other experiments of collateral bearing we here present and discuss.

We may state in advance that working with pure cultures as well as with soil composites, there is a great divergence in behavior of the same organisms when in soils and in solutions as regards nitrification,[2] denitratation, and ammonification; that some species or races affect their chemical changes in each medium, some in one only, others to different degrees in different media.

Bacteriological Methods.

In all instances strict bacteriological precautions were taken to avoid contamination of the test cultures. In cases of composite or crude inoculations with soil, the soil to be used was taken with aseptic precautions, and the water, media, glassware, etc., were sterile. Unless otherwise stated, the cultures were in cotton-stoppered, Erlenmeyer flasks, and were kept in a dark incubator room at a temperature varying from 30 degrees to 35 degrees. Calcium carbonate was added to all cultures. 400 grams of air-dry soil were used with water sufficient to render one-third saturated, unless otherwise stated.

Before sterilizing, the soil and nitrogenous material (except asparagin) were mixed, the water content made as desired, and the whole flasked, plugged, autoclaved for one hour at 120 degrees, and inoculated as desired. To sterilize asparagin a definite amount was weighed into a graduated flask, and enough ether added to cover the asparagin. After twenty-four hours the ether was evaporated, sterile water added, the asparagin dissolved and made up to a definite volume. The desired amount of this solution was taken with a sterile pipette.

[1] Since the publication of the brief abstract of this paper in Science, 27, p. 988. Fraps (Bul. 106, Tex. Agr. Exp. Sta. p. 8) has noted that nitrification does not proceed in saturated soils, and Lipman in his book "Bacteria in Relation to Country Life," p. 338, says that "With too much (moisture) nitrification was suspended." Failue to nitrify in an almost "waterlogged" sand was also noted by Hoffman (23rd Rept. Wis. Agr. Exp. Sta).

[2] Throughout this article we employ the term ***nitrification*** which has by many writers been used in many divers ways, in what seems its most logical meaning, to designate the change of ammoniacal nitrogen to nitrate nitrogen, and the term ***nitritation*** and ***nitratation*** to mean respectively change to nitrite and nitrate, as has been done by Winogradsky. The term ***denitratation*** is introduced to designate change from the nitrate to some other form containing less oxygen.

When it was desired to absorb solutions by soil, the soil to be used was dried in an air bath at 100-105 degrees, then 200 or 400 grams of this soil were flasked, plugged, sterilized, and the solution to be absorbed, previously inoculated, was poured upon it.

Three methods of inoculation have been employed: first the desired quantity of fresh soil (the inoculum) was poured into the flask on top of the soil to be inoculated and mixed by thorough shaking; second, the soil inoculum was weighed into a flask containing the nutrient solution, and this mixture poured onto the soil medium in the flask and mixed; third, a bacterial suspension was secured by adding 100 grams of soil to 200 cc. of sterile water and shaking three minutes. Inoculations were then made with the desired amount of the suspension.

Chemical Methods.

Soil Extract.—To the sample of 400 grams of soil were added 10 cc. of chloroform and water sufficient, with that originally in the soil, to make 1200 cc. Shaking in a shaking machine was continued for four hours. After standing over night, the solution was (1) poured off if sufficiently clear, or (2) filtered through a Pasteur-Chamberland filter,[1] or (3) after an aliquot part had been taken for the ammonia determination, the remainder was treated with lime and carbon black and filtered after precipitating the lime with a current of carbon dioxide.

Ammonia.—When nitrogen was added in the form of ammonium sulphate, it was expelled by boiling with a solution of sodium hydroxide. When it was added in organic forms, it was expelled by boiling in the presence of magnesium oxide. In either case the distillate was collected in one-fifth normal hydrochloric acid and titrated with one-tenth normal ammonium hydroxide solution, using cochineal as an indicator.

When the amount of nitrogen was less than the equivalent of 0.1 cc. of one-tenth normal ammonium hydroxide solution, the ammonia was liberated and collected in the same manner, but the amount was determined by Nesslerizing.

Nitrites and Nitrates.—The clarified solution was tested with diphenylamine,[2] which is sensitive to one part of nitrogen in the form of nitrite or nitrate in twenty millions or 0.05 milligrams nitrogen in one liter. In the case of soils where the dilution of the solution was approximately twenty times, the method would show 0.1 milligram nitrogen in 100 cc. of soil solution or about 0.06 milligram in 400 grams of soil.

Nitrites.—The sulphanilic acid method of Griess[3] was used for nitrites.

[1] Bureau of Soils U. S. Dept. Agr. Bul. No. 31. (1906) p. 12.
[2] Treadwell's Analytical Chemistry (1906), 1, p. 341.
[3] Bul. Soc. Chim. (3) 2, (1889); Bureau of Soils, U. S. Dept. Agr. Bul. 31, (1906), p. 41.

Nitrates.—Nitrates were usually determined by the Tiemann-Schulze method,[1] deduction being made for nitrites. When the amount of nitric oxide liberated was small, a correction was made for the amount insoluble in a concentrated solution of ferrous sulphate.

When the amount of nitrogen in the form of nitrates was very small, it was estimated by the phenol-disulphonic acid method.[2]

Explanation of Tables.

The amounts of ammonia, nitrites and nitrates are expressed in terms of the element nitrogen.

The amounts of nitrogen found at the end of the experiment in different forms of combination are expressed in terms of percentages of the nitrogen added at the beginning of the experiment and in terms of milligrams in 100 cc. of solution. In the case of soil, unless otherwise stated, the total amount of water present with 400 grams of soil was 60 cc., which was sufficient for one-third saturation. In preparing the samples for experiment, the amount of water added was sufficient, together with that originally present in the soil, to make 60 cc. approximately.

Table I.—Showing Nitrification of Both Ammonium

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1902	10-17-07	28	Live soil 1866	400	----------	----------	240	$(NH_4)_2SO_4$
1903	"	28	Sterile soil 1866	400	----------	----------	240	$(NH_4)_2SO_4$
1904	"	28	Live soil 1866	400	----------	----------	240	C. S. M.
1905	"	28	Sterile soil 1866	400	----------	----------	240	C. S. M.
1905a	"	28	Omelianski's solu	300	Soil 1866	5	127.3	$(NH_4)_2SO_4$

NITRIFICATION IN SOILS AND IN SOLUTIONS.

Experiment No. 32.—400 grams of soil, No. 1866, from the bed of the greenhouse were placed in a liter Erlenmeyer flask. Water, containing ammonium sulphate to amount of 240 milligrams of nitrogen, was added to make one-third saturation. Another flask was similarly prepared, except that the nitrogen was in the form of cotton-

[1] Treadwell's Anal. Chem. (1904), Vol. 2., p. 360. Zeit. f. Anal. Chem. 14 (1870) p. 401.

[2] Jour. Am. Chem. Soc. 16, (1894); 122, 193. Bureau of Soils, U. S. Dept. Agr. Bul. 31, (1906) p. 39.

seed meal. Check flasks similarly prepared, but sterile, were provided in each instance. The flasks were kept in the incubator room four weeks at 30-35 degrees.

At the same time Omelianski's solution,[3] containing ammonium sulphate, was inoculated with 5 grams of the same soil and maintained under the same conditions as were the soil cultures. The results appear in Table I.

It is here evident from the soil tests, both with ammonium sulphate and with cottonseed meal, that this soil is in a vigorous nitrifying condition, yet the tests by inoculation in solution give no indication of the presence of nitrate, even by diphenylamin, capable of indicating one part of nitrate in two millions. It may be added that this soil has never nitrified in solution sufficiently to give the diphenylamin reaction, though in soil tests it has repeatedly showed itself to be in reality a vigorous nitrifier.

The entire absence of ammonia in the cultures with cottonseed meal was so striking and unexpected that the samples were again analyzed on December 5, with confirmation of the fact that neither of the cottonseed meal flasks contained ammonia.

This raised the question whether the soil under study had any

Sulphate and Cottonseed Meal in Soils but Not in Solutions.

Sample Number.	Percentage of Initial Nitrogen.					Milligrams of Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total recovered.	Recovered as			Unaccounted for.	Total recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
1902	10.00	90.00	34.00	tr.	56.00	40.0	360.0	136.0	tr.	224.0
1903	12.40	87.60	82.00	0.20	5.60	49.6	350.4	328.0	0.8	22.4
Net					50.40				0.0	201.6
1904	54.00	46.00		tr.	46.00	216.0	184.0	0.0	0.0	184.0
1905	100.00					400.0		0.0	0.0	
Net					46.00				0.0	184.0
1905a			0.00					0.0		

ammonifying power, and tests were conducted, employing both peptone and cottonseed meal separately and inoculating with soil No. 1866. Each when tested at the end of eight days gave a considerable amount of ammonia, showing the soil to be in normal ammonifying condition. The only probable explanation of the absence of ammonia in this instance is that it was consumed by the nitrite organisms as fast as it was made. It appears also that the nitrite was likewise consumed by the nitrate organisms equally fast.

[3] Centr f. Bak. 2 Ab. 5 537-549.

TABLE II.—SHOWING NITRIFICATION OF BOTH AMMONIUM SULPHATE AND

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kinds.	Grams.	Kind.	Grams.	Milligrams.	Form.
1909	10-30-07	28	Live soil 1667	400			240	$(NH_4)_2SO_4$
1910	10-30-07	28	Live soil 1667	400			240	C. S. M.
1911	10-30-07	28	Live soil, plat 10	400			240	$(NH_4)_2SO_4$
1912	10-30-07	28	Live soil, plat 10	400			240	C. S. M.
1913	10-30-07	28	Live soil 1867	400			240	$(NH_4)_2SO_4$
1914	10-30-07	28	Live soil 1867	400			240	C. S. M.
1909a	10-30-07	28	Omelianski's solu.	300	Soil 1667	5	127.3	$(NH_4)_2SO_4$
1911a	10-30-07	28	Omelianski's solu.	300	Soil plat 10	5	127.3	$(NH_4)_2SO_4$
1913a	10-30-07	28	Omelianski's solu.	300	Soil 1867	5	127.3	$(NH_4)_2SO_4$

TABLE III.—SHOWING FAILURE TO NITRIFY IN

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2546	8-24-08	28	Live soil 1931a	400			240	$(NH_4)_2SO_4$
2547	8-24-08	28	Live soil 1931a	400			240	$(NH_4)_2SO_4$
2548	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931a.	10	160	$(NH_4)_2SO_4$
2549	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931a.	10	160	$(NH_4)_2SO_4$
2550	8-24-08	28	Live soil 1931b	400			240	$(NH_4)_2SO_4$
2551	8-24-08	28	Live soil 1931b	400			240	$(NH_4)_2SO_4$
2552	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931b.	10	160	$(NH_4)_2SO_4$
2553	8-24-08	28	Omelianski's solution.	377.12	Suspension of soil 1931b.	10	160	$(NH_4)_2SO_4$

Experiment No. 34.—Three samples of soils Nos. 1667, 1867 and plat 10, 400 grams each, were taken. The soils were made to one-third saturation with water carrying 240 milligrams of nitrogen, either as ammonium sulphate or as cottonseed meal. Simultaneous inoculations were made into Omelianski's ammonia solution, using 5 grams of soil as the inoculum. All were done in duplicate. The results are given in Table II.

It is noted in this instance two of the three samples failed utterly

Cottonseed Meal by Soil No. 1867 in Soil but Not in Solution.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
1909	12.20	87.80	87.80	tr.	0.00	73.2	526.8	526.8	tr.	0.0
1910	81.50	18.50	18.50	tr.	0.00	489.0	111.0	111.0	tr.	0.0
1911	20.70	79.30	79 30	tr.	0.00	124.2	475.8	475.8	tr.	0.0
1912	82.40	17.60	17.60	tr.	0.00	494 4	105.6	105.6	tr.	0.0
1913	1.70	98.30	42.10	tr.	56.20	6.8	393.2	168.4	tr.	224.8
1914	7.30	92.30	42.10	tr.	50.20	29.2	370.8	168.4	tr.	200.8
1909a			0.00	tr.	0.00			0 0		
1911a			0.00	tr.	0.00			0.0		
1913a			0.00	tr.	0.00			0.0		

Solution but Vigorous Nitrification in Soils.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2546			66.52	0.34	3.38			133.0	0.7	6.8
2547			67.78	1.50	8.45			135.6	3.0	16.9
aver.	26.93	73.07	67.15	0.92	5.92	53.9	146.1	134.3	1.8	11.8
2548			93.78	0.00	0.00			39.8	0.0	0.0
2549			95.36	0.00	0.00			40.9	0.0	0.0
aver.	4.93	95.07	95.07	0.00	0.00	2.1	40.4	40.4	0.0	0.0
2550			53.91	0.85	33.20			107.8	1.6	66.4
2551			62.46	0.88	7.39			124.9	1.8	14.6
aver	21.68	78.32	58.18	0.87	20.24	42.7	157.3	116.3	1.7	41.0
2552			93.60	0.00	0.00			39.8	0.0	0.0
2553			94.38	0.00	0.00			40.1	0.0	0.0
aver.	6.12	93.98	93.98	0.00	0.00	2.6	39.9	39.9	0.0	0.0

to nitrify either in soil or in solution, but that one sample, soil No. 1867, nitrified strongly in soil, though not at all in solution. This soil itself was known to be nearly free from nitrates.

Experiment No. 108.—Two soils were inoculated in duplicate into soils, and at the same time in duplicate into Omelianski's solution. The results in Table III give another instance of failure to nitrify in solutions, though nitrification in soil was vigorous. Though no checks were run, it is known that soil No. 1931 contained practi-

TABLE IV.—SHOWING BETTER NITRIFICATION IN SOIL

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind	Grams.	Milligrams.	Form.
2046	2-10-08	28	Sterile soil 1867	300	Soil 1867	10	240	$(NH4)_2SO_4$
2047	2-10-08	28	Sterile soil 1867	300	Soil 1867	10	240	$(NH4)_2SO_4$
2048	2-10-08	28	Omelianski's solu.	300	Soil 1867	10	127.3	$(NH4)_2SO_4$
2049	2-10-08	28	Wiley's solution	300	Soil 1867	10	12.73	$(NH4)_2SO_4$
2050	2-10-08	28	Extract of soil 1867	300	Soil 1867	10	127.3	$(NH4)_2SO_4$
2054	2-10-08	28	Omelianski's solu.	300	Soil 1867	.2	127.3	$(NH4)_2SO_4$
2055	2-10-08	28	Wiley's solution	300	Soil 1867	.2	12.73	$(NH4)_2SO_4$

cally no nitrate, and that the nitrate shown in this table is the result of nitrification during the experiment.

Experiment No. 72.—Cultures were tested by using soil extract as a medium, to ascertain whether some deficiency in the chemical constitution of the solutions used, which might not exist in soil extract itself, was responsible for the failure to nitrify in solutions.

Tests were also made in Wiley's solution[1] and Omelianski's solution using 10 grams of inoculum. The results secured at the end of four weeks are given in Table IV.

The contrast is here again strong between soil cultures Nos. 2046 and 2047, which either upon a basis of percentage of nitrification or upon a basis of milligrams nitrified per cc. of solution show a much greater nitrification than cultures in Omelianski's solution, (Nos. 2048 and 2054), which practically failed to nitrify at all. While the percentage of nitrification in Nos. 2049 and 2055 in Wiley's solution is high, this is not significant, since the absolute amount of nitrates is so small as to be almost negligible. Note initial amounts of nitrogen present. A more nearly correct comparison regarding the nitrifying power of these samples is shown in the last column, indicating only slight nitrification in the liquid medium. While there was nitrification in the soil extract No. 2050, it fell far short of that occurring in the soil itself. While this experiment, taken alone, would tend to indicate that soil extract contains something favorable to nitrification which is lacking in the artificial solutions, this conclusion is not supported by other evidence. The conclusion that soil as a medium furnishes a much more sensitive means for detection of nitrification than do the usual solutions, is, however, supported by the evidence throughout.

[1] Wiley, Yearbook, U. S. Dept. Agr. for 1895, p. 97.

THAN IN SOIL EXTRACT OR IN THE USUAL CULTURE SOLUTIONS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen Per 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2046	19.00	81.00	59.50	0.10	21.50	76.0	324.0	238.0	0.0	86.0
2047	10.00	90.00	64.40	0.00	25.60	40.0	360.0	257.6	0.0	102.4
aver.	14.50	85.50	61.95	0.05	23.55	58.0	342.0	247.8	0.0	94.2
2048	1.20	98.80	97.00	0.00	1.80	0.5	42.0	41.2	0.0	0.8
2049	12.90	87.10	42.90	0.00	44.20[2]	0.6	3.7	1.8	0.0	1.9
2050	5.70	94.30	81.20	0.10	13.10	2.4	40.1	34.5	tr.	5.6
2054	12.20	87.80	87.10	0.00	0.70	5.5	37.0	37.0	0.0	tr.
2055	9.70[1]	109.70	102.30	0.00	7.40[2]	0.41[1]	4.7	4.4	0.0	0.3

[1] Excess.
[2] This percentage has slight significance because of the small amount of initial nitrogen.

Experiment No. 72.—Duplicate cultures of this experiment were analyzed at the end of sixty-four days. During this additional time some slight nitrification had occurred in the cultures which showed no nitrification at first analysis, but the superiority of soil as a medium for nitrification is even more apparent at the second than at the first analysis. (Compare Tables IV and V, last column.)

Basing nitrification upon the amount of nitrate produced per 100 cc. of solution, it is seen that the process is sixty-eight times as rapid in the soil water *in situ* as it is in Omelianski's or Wiley's solutions, and thirty-nine times as fast as it is in an extract of the same soil.

It seems clear from this experiment that not only are results of four week tests in solutions, such as those of Wiley, Omelianski or Ashby, worthless as indicative of the nitrifying powers of soils tested by them, but that results which are negative at the end of four weeks may indicate some nitrification if the cultures be allowed to stand for a longer time.

Experiment No. 73.—To 400 grams each of live soils Nos. 1867, 1667 and 2069 were added in the usual way 240 milligrams of nitrogen as cottonseed meal.

Flasks of Omelianski's and of Wiley's solutions were also inoculated with each of these soils. Determinations were made upon all after four weeks' incubation.

The results are presented in Table VI.

In the last column of Table VI it is noted that soils Nos. 1867 and 2069 gave a large nitrification in soil, but a nearly negligible quantity in Omelianski's or Wiley's solutions, while the third soil failed to nitrify to any extent in any medium.

TABLE V.—SHOWING RESULTS OF NITRIFICATION

Sample Number.	Date of Inoculation.	Days of Incubation.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2165	2-10-08	64	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
2166	2-10-08	64	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
2167	2-10-08	64	Omelianski's solution.	300	Soil 1867	10	127.3	$(NH_4)_2SO_4$
2168	2-10-08	64	Wiley's solution	300	Soil 1867	10	12.73	$(NH_4)_2SO_4$
2169	2-10-08	64	Extracts of soil 1867.	300	Soil 1867	10	127.3	$(NH_4)_2SO_4$
2173	2-10-08	64	Omelianski's solution.	300	Soil 1867	.2	127.3	$(NH_4)_2SO_4$
2174	2-10-08	64	Wiley's solution	300	Soil 1867	.2	12.73	$(NH_4)_2SO_4$

TABLE VI.—SHOWING NITRIFICATION

Number Sample.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kinds.	Grams.	Kind.	Grams.	Milligrams.	Form.
2060	2-13-08	28	Live soil 1867	400			240	C. S. M. 2
2057	2-13-08	28	Sterile soil 1867	400			0.12	C. S. M.
2061	2-13-08	28	Live soil 1667	400			240	C. S. M.
2058	2-13-08	28	Sterile soil 1667	400			0.12	C. S. M.
2062	2-13-08	28	Live soil 2069	400			240	C. S. M.
2059	2-13-08	28	Sterile soil 2069	400			0.12	C. S. M.
2063	2-13-08	28	Wiley's solution	300	Soil 1867	.2	12.7	$(NH_4)_2SO_4$
2064	2-13-08	28	Wiley's solution	300	Soil 1667	.2	12.7	$(NH_4)_2SO_4$
2065	2-13-08	28	Wiley's solution	300	Soil 2069	.2	12.7	$(NH_4)_2SO_4$
2066	2-13-08	28	Omelianski's sol	300	Soil 1867	.2	127.	$(NH_4)_2SO_4$
2067	2-13-08	28	Omelianski's sol	300	Soil 1667	.2	127.	$(NH_4)_2SO_4$
2068	2-13-08	28	Omelianski's sol	300	Soil 2069	.2	127.	$(NH_4)_2SO_4$

TESTS IN SOLUTIONS AND IN SOILS AT 64 DAYS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2165	6.80[1]	106.80	30.80	0.00	76.00	27.2[2]	427.2	123.2	0.0	304.0
2166	1.20[1]	101.20	23.80	0.00	77.40	4.8[2]	404.8	95.2	0.0	309.6
aver.	4.00[1]	104.00	27.30	0.00	76.70	16.0[2]	416.0	109.2	0.0	306.8
2167	3.00[1]	103.00	92.40	0.00	10.60	1.3[2]	43.8	39.3	0.0	4.5
2168	3.40	96.60	6 60	0.00	90.00[1]	0.2	4.1	0.3	0.0	3.8
2169	4.70	95.30	77.20	0.00	18.10	2.0	40.5	32.8	0.0	7.7
2173	6.90[1]	106.90	97.70	1.30	9.20	2.8[2]	45.3	41.4	0.6	3.9
2174	1.60[1]	101.60	26.40	tr.	75.20[1]	0.1[2]	4.3	1.1	tr.	3.2

[1] Excess.

[2] These percentages have small significance because of the small amount of nitrogen.

IN SOILS, NOT IN SOLUTIONS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2060	----	----	----	----	----	155.6	244.4	14.0	0.0	230.4
2057	----	----	----	----	----	0.4	2.4	2.4	0.0	1.6
net	39.90	60.10	2.90	0.00	57.20	158 0	242.0	11.6	0.0	228.8
2061	----	----	----	----	----	318.0	82.0	78.4	0.0	3.6
2058	----	----	----	----	----	1.0	1.0	0.6	0.0	0.4
net	79.75	20.25	19.45	0.00	0.80	319.0	81.0	77.8	0.0	3.2
2062	----	----	----	----	----	260.0	140.0	33.6	6.4	106.4
2059	----	----	----	----	----	1.3	0.7	0.3	0.0	0.4
net	65.18	34.82	8.32	1.60	24.90	260.7	139.3	33.3	6.4	99.6
2063	41.00	59.00	0.00	3.60	59.00[1]	1.8	2.5	0.0	0.2	2.5
2064	41.90	58.10	33.00	0.00	25.10[1]	1.8	2.5	1.4	0.0	1.1
2065	50.10	49.90	39.60	tr.	10.30[1]	2.2	2.1	1.7	tr.	0.4
2066	55.10	44.90	40.90	0.20	4.00	23.4	19.1	17.4	tr.	1.7
2067	61.40	38.60	37.60	tr.	1.00	26.1	16.4	16.0	tr.	0.4
2068	50.90	49.10	48.10	tr.	11.00	21.7	20.8	20.4	tr.	0.4

[1] Not significant on account of the very small amount of initial nitrogen.

[2] C. S. M.—Cottonseed Meal.

TABLE VII.—SHOWING NITRIFICATION IN

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2025	2-10-08	14	Sterile soil 1867	490	Soil 1867	10	120	Peptone.
2026	2-10-08	14	Sterile soil 1867	490	Soil 1867	10	120	C. S. M.
2027	2-10-08	14	Peptone water	200	Soil 1867	10	60	Peptone.
2028	2-10-08	14	C. S. M. water	200	Soil 1867	10	60	C. S. M.

TABLE VIII.—SHOWING INFLUENCE OF NUMBER

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1962	12-2-08	28	Sterile soil 1867	390	Soil 1867	10	240	$(NH_4)_2SO_4$
1963	12-2-08	28	Sterile soil 1867	350	Soil 1867	50	240	$(NH_4)_2SO_4$
1964	12-2-08	28	Sterile soil 1867	300	Soil 1867	100	240	$(NH_4)_2SO_4$
1965	12-2-08	28	Sterile soil 1867	200	Soil 1867	200	240	$(NH_4)_2SO_4$
1966	12-2-08	28	Live soil 1867	400			240	$(NH_4)_2SO_4$
1967	12-2-08	28	Sterile soil 1867	400			240	$(NH_4)_2SO_4$

Making proper allowance for the very small quantity of initial nitrogen in Omelianski's and Wiley's solutions, the same conclusion is reached from the percentage of nitrogen recovered as nitrates. Two of the soils could nitrify vigorously in soils but only slightly in solutions.

Experiment No. 69a.—Four cultures were made; two in soils, one with peptone and one with cottonseed meal; two in solutions, one with peptone and one with cottonseed meal. They were inoculated in parallel with the same bacterial suspensions from soil No. 1867. Analysis on the fourteenth day gave the results shown in Table VII.

While nitrification progressed to a marked extent in both soil cultures, the solutions gave no reaction with diphenylamin. Though no checks were run with this test to determine the amounts of nitrates in these soils, our constant experimentation with them and frequent analyses assure us that there was barely a trace, or no nitrate at all, present in the soil when the experiment was set up. The amount shown by the analysis is due to nitrification during the experiment.

Experiments 56 and 57.—It seemed possible that the amount of

14 Days in Soils, Not in Solutions.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2025	51.60	48.40	11.20	1.50	37.20	103.2	96.8	22.4	3.0	74.4
2026	66.30	33.70	2.80	1.50	30.90	132.6	67.4	5.6	3.0	61.8
2027	29.60	70.40	70.40	0.00	0.00	8.9	21.1	21.1	0.0	0.0
2028	61.70	38.30	38.30	0.00	0.00	18.5	11.5	11.5	0.0	0.0

of Bacteria Upon Rapidity of Nitrification.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
1962	--------	--------	60 90	0.20	lost.	--------	--------	243.6	0.8	lost.
1963	29.90	71.10	53.20	0.20	17.90	115.6	284.6	212.8	0.8	71.6
1964	34.20	65.80	42.70	0.20	23.10	136.8	263.2	170.8	0.8	97.4
1965	21.40	78.60	44.10	0.20	34.50	85.6	314.4	176.4	0.8	138.0
1966	4.60[1]	104.60	12.60	0.20	91.80	17.6[1]	417.6	50.4	0.8	367.2
1967	31.20	68.80	68.60	0.20	0.00	124.8	275.2	274.4	0.8	0.0

[1] Excess.

inoculum used might be an important factor in determining the amount, or at least the rapidity, of nitrification in early stages of incubation. To throw light upon this point, parallel cultures were made by mixing the same soil, sterile and alive, in different proportions, thus varying practically only one factor, the quantity of live organisms present. Experiment 56 consisted of such a series with nitrogen supplied in the form of ammonium sulphate; experiment 57, with nitrogen in the form of cottonseed meal.

The results are given in Tables VIII and IX.

In Table VIII there is shown a remarkably regular increase in nitrification as the quantity of inoculum increases. In Table IX, where cottonseed meal was used, if the third result be disregarded, the same relation holds true. The discrepancy in the behavior of soil No. 1970 is inexplicable, but it probably does not vitiate the general conclusions supported by these two experiments, viz, that with increase in the inoculum there is nearly a corresponding increase in the total amount of nitrification at the end of four weeks.

When tests of nitrifying power are made in the soil itself, by add-

TABLE IX.—SHOWING INFLUENCE OF QUANTITY OF BACTERIA

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1968	12-5-08	28	Sterile soil 1867	390	Soil 1867	10	240	C. S. M.
1969	12-5-08	28	Sterile soil 1867	350	Soil 1867	50	240	C. S. M.
1970	12-5-08	28	Sterile soil 1867	300	Soil 1867	100	240	C. S. M.
1971	12-5-08	28	Sttrile soil 1867	200	Soil 1867	200	240	C. S. M.
1972	12-5-08	28	Live soil 1867	400			240	C. S. M.
1973	12-5-08	28	Sterile soil 1867	400			240	C. S. M.

TABLE X.—SHOWING NO NITRIFICATION IN SOLUTIONS

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
1974	12-12-07	28	Sterile soil 1867 Water	399.5 200	Soil 1867	0.5	360	C. S. M.
1975	12-12-07	28	Sterile soil 1867 Water	300 200	Soil 1867	100	360	C. S. M.
1976	12-12-07	28	Live soil 1867 Water	400 200			360	C. S. M.
1977	12-12-07	28	Sterile soil 1867 Water	399.5 200	Soil 1867	0.5	360	$(NH_4)_2SO_4$
1978	12-12-07	28	Sterile soil 1867 Water	300 200	Soil 1867	100	360	$(NH_4)_2SO_4$
1979	12-12-07	28	Live soil 1867 Water	400 200			360	$(NH_4)_2SO_4$

ing the material to be nitrified directly to the soil, it is evident that there is initially a much larger number of organisms than when 200 milligrams or even 10 grams of the soil are used as an inoculum. We may regard the direct soil tests in our work as having the equivalent of an inoculum of 400 grams.

The idea that increase in the quantity of the inoculum brings increase in nitrification arouses the suspicion that perhaps the low nitrification, or entire failure to nitrify, found by the Ashby[1] method with an inoculum of only 200 milligrams of soil, may be due to the smallness of the inoculum used.

Experiment No. 58.—This experiment was set up to test this lat-

[1] Jour. Chem. Soc. 85, 1158.

Upon Rapidity of Nitrification of Cottonseed Meal.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites	Nitrates.			Ammonia.	Nitrites	Nitrates
1968	76.20	23.80	17.50	tr.	6.30	304.8	95.2	70.0	tr.	25.2
1969	70.10	29.90	13.30	tr.	16.60	280.4	119.6	53.2	tr.	66.4
1970	74.50	25.50	22.40	tr.	3.10	298.0	102.0	89.6	tr.	12.4
1971	60.20	39.80	4.90	tr.	34.90	240.8	159.2	19.6	tr.	139.6
1972	53.60	47.00	0.00	tr.	47.00	212.0	188.0	0.0	tr.	188.0
1973	97.50	2.50	0.00	tr.	2.50	390.0	10.0	0.0	tr.	10.0

C. S. M.—Cottonseed Meal.

Even When Very Large Inoculum was Used.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
1974	70.60	29.40	29.40	0.00	0.00	97.8	40.7	40.7	0.0	0.0
1975	48.90	51.10	51.10	tr.	0.00	67.7	70.8	70.8	tr.	0.0
1976	78.30	21.70	21.70	0.00	0.00	108.4	30.1	30.1	0.0	0.0
1977	45.40	54.60	54.60	0.00	0.00	62.9	75.6	75.6	0.0	0.0
1978	lost	lost	lost	lost	0.00	lost	lost	lost	lost	0.0
1979	43 20	56.80	56.70	tr.	0.00	60.0	78.5	78.5	tr.	0.0

C. S. M.—Cottonseed Meal.

ter point: to determine whether the failure to nitrify in solutions can fairly be attributed to the smallness of the inoculum used.

A series of tests was made in solutions, varying the amount of inoculum. In order to maintain conditions as nearly parallel as possible, the quantity of soil used in each case was the same, larger or smaller amounts of it being sterilized to give the desired variations in the number of live organisms present.

Thus in soil No. 1974, 399.5 grams of sterile soil+0.5 gram of the same live soil were used, while in No. 1979, 0 grams of sterile soil+400 grams of live soil were used. The other numbers gave intermediate conditions. Solution sufficient to cover the soil to a depth of 2.5 cm. was employed in each case, the solution also carried nitrogen

TABLE XI.—SHOWING FAILURE TO

Nitrogen 240 Mgs. as Ammonium Sulphate.

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.	
			Kind.	Amount.	Kind.	Amount.
2621	9-10-08	28	Sterile soil 1549 Water to ⅔ saturat'n	400 60	Suspension of Soil number 1867	10
2622	9-10-08	28	Sterile soil 1549 Water to ⅔ saturat'n	400 60	Suspension of Soil number 1867	10
2623	9-10-08	28	Sterile soil 1549 Water to saturat'n	400 100	Suspension of Soil number 1867	10
2624	9-10-08	28	Sterile soil 1549 Water to saturat'n	400 100	Suspension of Soil number 1867	10
2627	9-10-08	28	Sterile soil 1783 Water to ⅔ saturat'n	400 100	Suspension of Soil number 1867	10
2628	9-10-08	28	Sterile soil 1783 Water to ⅔ saturat'n	400 100	Suspension of Soil number 1867	10
2629	9-10-08	28	Sterile soil 1783 Water to saturati'n	400 144	Suspension of Soil number 1867	10
2630	9-10-08	28	Sterile soil 1783 Water to saturati'n	400 144	Suspension of Soil number 1867	10
2631	9-10-08	28	Sterile soil 1931 Water to ⅓ satutat'n	400 60	Suspension of Soil number 1867	10
2632	9-10-08	28	Sterile soil 1931 Water to ⅓ saturat'n	400 60	Suspension of Soil number 1867	10
2635	9-10-08	28	Sterile soil 1931 Water to saturation	400 180	Suspension of Soil number 1867	10
2636	9-10-08	28	Sterile soil 1931 Water to saturation	400 180	Suspension of Soil number 1867	10

at the rate of 240 milligrams per 400 cc. The culture was frequently shaken, sampled, and tested by diphenylamine with negative results. At the end of four weeks, analysis was also made with still no nitrification, as is shown in Table X.

A comparison of these results with those of experiments 56 and 57, which were inoculated with the same soils, brings out again clearly the failure of the soil to nitrify at all in the solutions, although the same soil can nitrify vigorously in the same period, as is shown by actual soil tests.

Experiment No. 58 demonstrates conclusively that the differences existing between results of cultures in soils and in solutions are not to be explained by the differences in the quantities of inoculum used.

Experiment 211.—It being demonstrated that the water relation is a very important one as regards nitrification, and that nitrification proceeds not at all, or very slightly in solutions, during the time of our experiments with the soils under consideration, but vigorously in the soil itself, it became desirable to determine whether nitrification can proceed in saturated soils as well as in those of less water con-

NITRIFY IN SATURATED SOILS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2621	-------	-------	24.51	2.25	24.29	-------	-------	98.0	9.0	97.2
2622	-------	-------	24.09	3.37	26.08	-------	-------	96.4	13.5	104.3
aver.	50.52	49.48	24.30	2.81	25.18	202.1	197.9	97.2	11.3	100.7
2623	-------	-------	50.41	0.10	0.00	-------	-------	121.0	0.3	0.0
2624	-------	-------	52.79	0.10	0.00	-------	-------	125.4	0.3	0.0
aver.	48.30	51.70	51.60	0.10	0.00	116.5	123.5	123.2	0.3	0.0
2627	-------	-------	16.80	0.25	23.82	-------	-------	40.3	0.6	57.2
2628	-------	-------	22.41	0.37	22.86	-------	-------	53.8	0.9	54.8
aver.	57.06	42.94	19.60	0.31	23.33	134.9	103.1	47.1	0.8	56.0
2629	-------	-------	63.02	0.10	0.00	-------	-------	105.0	0.2	0.0
2630	-------	-------	57.42	0.12	0.00	-------	-------	95.7	0.2	0.0
aver.	39.67	60.33	60.22	0.11	0.00	66.2	100.5	100.3	0.2	0.0
2631	-------	-------	35.01	0.23	44.79	-------	-------	140.0	0.9	179.2
2632	-------	-------	26.01	0.23	46.67	-------	-------	126.4	0.9	186.7
aver.	23.76	76.24	30.51	0.23	45.73	84.0	316.0	133.2	0.9	182.8
2635	-------	-------	43.41	0.10	tr.	-------	-------	57.9	0.1	tr.
2636	-------	-------	45.51	0.10	tr.	-------	-------	60.7	0.1	tr.
aver.	55.44	44.56	44.46	0.10	tr.	73.9	59.4	59.3	0.1	tr.

tent. To this end cultures in three different soils were prepared, some bearing water to one-third, two-thirds, and some to complete saturation. The cultures were inoculated with a suspension of soil No. 1867.

The results are given in Table XI.

It is seen that there was no trace of nitrification in the saturated soil in the case of two soils and only a trace with the other soil, though nitrification proceeded well in all soils when of two-third or one-third saturation.

In order to have a still more crucial test of nitrifying activity in soil as compared with that in solution, two portions of Omelianski's solution were prepared in the usual way, inoculated; one lot was incubated as a solution, the other portion was absorbed by sterile soil of such quantity as to render the culture about two-thirds saturated. Also an extract of soil with ammonium sulphate added to it in the usual quantity was inoculated and similarly mixed with soil. Suitable control cultures were set up. The results are given in Table XII.

TABLE XII.—SHOWING AMOUNT OF NITRIFICATION IN SOLUTION

Sample Number.	Date of Inoculation.	Time of Incubation, Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2034	2-3-08	28	Omelianski's sol.	240	Soil 1867	10	101.8	$(NH_4)_2SO_4$
2035[1]	2-3-08	28	Sterile soil 1867	400	Soil 1867	5	50.9	$(NH_4)_2SO_4$
2036	2-3-08	28	Ext'ct of soil 1867	240	Soil 1867	10	101.8	$(NH_4)_2SO_4$
2038	2-3-08	28	Ext'ct of soil 1867	240	Soil 1867	10	101.8	$(NH_4)_2SO_4$
2037[1]	2-3-08	28	Sterile soil 1867	400	Soil 1867	5	50.9	$(NH_4)_2SO_4$
2039	2-3-08	28	Sterile soil 1867	400	Soil 1867	5	50.9	$(NH_4)_2SO_4$

TABLE XIII.—SHOWING NITRIFICATION BY

Sample Number.	Date of Inoculation.	Time of Incubation. Days.	Medium.		Inoculum.		Initial Nitrogen.	
			Kind.	Grams.	Kind.	Grams.	Milligrams.	Form.
2051	2-8-08	28	Sterile soil 1867	390	Percolator effluent	10	240	$(NH_4)_2SO_4$
2052	2-8-08	28	Sterile soil 1867	390	Percolator effluent	10	240	$(NH_4)_2SO_4$
2053	2-9-08	28	Ext'ct of soil 1867	300	Percolator effluent	10	127.3	$(NH_4)_2SO_4$

It is seen from the first two numbers that, making proper allowances for the results of the control cultures, nitrification was vastly greater in the solution absorbed by soil than in the same solution not so absorbed, a conclusion which is clearly justified either by basing nitrification upon a per cent basis or on the amount of nitrate produced per 100 cc. of liquid in the medium.

NITRIFYING SEWER ORGANISMS.

Small quantities of nitrifying earth from the sewer beds of Lawrence, Mass., were obtained through the kindness of Dr. Stephen DeM. Gage. These samples, thrown into ammonium sulphate solution, nitrified vigorously from the start. A quantity of finely ground coke was placed in a percolator, inoculated with this nitrifying sewer-

AND IN THE SAME SOLUTION ABSORBED BY SOILS.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates.
2034	21.60	78.40	53.50	tr.	24.90	9.2	33.3	22.7	tr.	10.6
2035	14.01[2]	114.00	0.00	0.00	114.00	6.0[2]	48.5	0.0	0.0	48.5
2036	37.20	62.80	47.20	1.60	14.00	16.5	26.0	20.0	0.7	6.0
2038	95.70	4.30	0.00	0.40	3.90	40.8	1.7	0.0	0.2	1.7
net				1.20	10.10				0.5	4.
2037	11.60[2]	111.60	0.00	0.00	111.60	4.9	47.4	0 0	0.0	47.4
2039	58.50	41.50	19.80	0.00	21.70	24.9	17.6	8.4	0.0	9.2
net				0.00	89.90				0.0	38.2

[1] In 2035, 120 cc. of Omelianski's solution were inoculated with 5 g of soil 1867 and then poured over 400 g. of sterile soil. In 2037, 120 cc. soil extract + ammonium sulphate were inoculated and then poured on soil in s'milar manner.
[2] Excess.

SEWER ORGANISMS IN SOIL AND IN SOLUTION.

Number.	Percentage of Initial Nitrogen.					Milligrams Nitrogen in 100 cc. Solution.				
	Unaccounted for.	Total Recovered.	Recovered as			Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrites.	Nitrates.			Ammonia.	Nitrites	Nitrates
2051	10.60	89.40	80.50	0.00	8.90	42.4	357.6	322.0	0.0	35.6
2052	19.60	80.40	73.50	0.00	6.90	78.4	321.6	294.0	0.0	27.6
aver	15.10	84.90		0.00	7.90	60.4	339.6	309.0	0.0	31.6
2053	1.80[1]	101.80	86.50	0.00	15.30	0.8[1]	43.3	36.8	0.0	6.5

[1] Excess.

bed material and ammoniacal solution poured through it once or twice daily. In this manner the coke of the percolator soon came to a still more vigorous nitrifying condition.

The effluent from this percolator formed excellent inoculating material for nitrification.

Experiment No. 72.—Inoculations were made into soil and into soil extract with the nitrifying effluent from the coke-filled percolator bearing the sewer organisms. The cultures were analyzed at the end of twenty-eight days with the results shown in Table XIII.

These cultures nitrified more vigorously in solutions than any cultures heretofore examined, and more vigorously than any of the soils among the many that we have tested during the past two years. Not only this, but basing the nitrification upon the number of grams of

TABLE XIV.—SHOWING FAILURE OF PURE

Nitrogen 240 Mgs. as Ammonium Sulphate.

Sample Number.	Date of Inoculation.	Days from Inoculation to Analysis.	Medium.		Inoculum.	
			Kind.	Amount.	Kind.	Amount.
2606	9-7-08	28	Sterile 1867 Water to ⅓ saturation	400 60	Organism {ite ate	1 cc.
2607	9-7-08	28	Sterile 1867 Water to ⅓ saturation	400 60	Organism {ite ate	1 cc.
2610	9-7-08	28	Sterile 1867 Water to saturation	400 180	Organism {ite ate	1 cc.
2611	9-7-08	28	Sterile 1867 Water to saturation	400 180	Organism {ite ate	1 cc.

nitrogen in the medium, it is seen that there was a larger per cent of nitrification in the solution than in the soil culture, a condition which is also without parallel in our experiments with cultures inoculated with soils.

In numerous tests, this sewer culture has proved a vigorous nitrifier in ammoniacal solutions of various compositions; it also nitrifies well in soil.

Here then is, evidently, a nitrifying organism or group of nitrifying organisms, differing radically in physiological relations from those usually found in soils here, in that it can nitrify even better in solutions than in soils.

TEST WITH PURE CULTURES.

Experiment 210.—Tests of nitrification in the presence of different amounts of water were also made, using as the inoculum 1 cc. each of cultures of pure nitrite and nitrate forming organisms[1] isolated by the Stevens-Temple silicate medium.[2]

The results of this experiment are given in Table XIV.

Here again there was large nitrification in soil cultures of one-third saturation, but no nitrification in the saturated soils.

This result is particularly significant in that it shows that the failure to find nitrates in solution and in very wet soils is in no way due to their reduction or destruction otherwise by organisms accidentally present.

[1] These cultures were pure in the sense that Winogradsky used the term, i. e., they would not render bouillon turbid, and they formed nitrite or nitrate respectively from appropriate lower nitrogen compounds.

[2] A convenient mode of preparing Silicate Jelly Cent. f. Bak. II ab. 21, 1908. 84.

CULTURE TO NITRIFY IN SATURATED SOILS.

Number.	Percentage of Initial Nitrogen.					Miligrams Nitrogen in 100 cc. Solution.					
	Unaccounted for.	Total Recovered.	Recovered as			Initial.	Unaccounted for.	Total Recovered.	Recovered as		
			Ammonia.	Nitrite.	Nitrate.				Ammonia.	Nitrite.	Nitrate.
2606	-------	-------	45.51	0.15	12.53	400	------	------	182.	0.6	50.1
2607	-------	-------	46.35	0.38	11.06	400	------	------	185.4	1.5	44.2
aver	42.29	57.71	45.93	0.26	11.78	400	169.1	230.9	183.7	1.	47.2
2610	-------	-------	44.11	0.07	0.00	133	------	------	58.7	tr.	0.0
2611	-------	-------	44.74	tr.	0.00	133	------	------	59.5	tr.	0.0
aver	65.53	44.47	44.47	0.04	0.00	133	73.9	59.1	59.1	tr.	0.0

BASIS FOR COMPARISON.

It is difficult to determine what is the most useful basis for comparing bacterial activity in soils with the activity of bacteria in solutions, whether to base the comparison on:

(1) The per cent of nitrogen originally present that is converted into some other form of nitrogen, or

(2) To compare the number of milligrams of nitrogen converted per cubic centimeter of solution with the number of milligrams of nitrogen per cubic centimeter of soil water so converted, or

(3) To compare the number of milligrams of nitrogen converted per cubic centimeter of solution with the number of milligrams of nitrogen converted per gram of moist soil.

To compare the percentages of original nitrogen converted in two different media, one weak and the other strong, as in Nos. 2049 and 2055 (see Table IV), is manifestly an unfair measure of the nitrifying power of the cultures, since a very weak nitrifier might bring about a nitrification of nearly 100 per cent in the weak medium, while a very vigorous nitrifier might nitrify to less than 40 per cent in the more concentrated medium. In such instances, a comparison of the number of milligrams of nitrogen converted per gram of medium or per cc. of liquid present, is more significant, though this comparison would also be improper, if the nitrification reached such an amount in the weaker medium as to justify the belief that cessation of nitrification was caused by lack of suitable material to work upon.

The nitrifying organisms undoubtedly live and function in the moisture in the soil, so that from the viewpoint of measuring the

activity of the organisms, the second method mentioned above seems most useful. This method of comparison, however, probably tends to exaggerate the value of the changes occurring, and from a practical viewpoint, a comparison by the third method is probably the most serviceable, since it pictures approximately the relative nitrifying power of two cultures of equal weight. Each comparison has its special uses, and to enable the readers to make such comparisons as are desired, data are given to admit of the use of each of the comparisons suggested.

A comparison of nitrification in soils with nitrification in solutions is probably of very little significance except for the special purpose of this present article, unless some relation can be established showing that the vigor of nitrification in a certain solution can be taken as an index of the nitrifying vigor of the soil used to inoculate the solution.

General Considerations.

The evidence of the tables presented, together with the results of numerous other experiments during our experience of the last two years, forces the conclusion that not all soils which can bring about vigorous nitrification of ammonium sulphate and cottonseed meal in soils in four weeks can nitrify in solutions during that time. Numerous instances show that among the natural soils of this locality few or none can cause nitrification in solution in four weeks, if at all. It is established also that some of these soils which cause nitrification not at all or slightly in Omelianski's, Ashby's, Wiley's, or other ammoniacal solutions, can still nitrify vigorously as soils. It is also brought out that the failure to nitrify is not due to the fact that a small inoculum is used in solution, since in the experiments given in detail there was no nitrification even when 400 grams of the live soil were used as an inoculum, and repeated experiments have also shown that the presence of water to or above the point of saturation inhibits nitrification with the soils here used. Notwithstanding this fact, sewer-bed soil nitrified as well in solutions as it did in soils.

From these facts, it seems that no trustworthy, reliable evidence as to the actual nitrifying power of a soil can be gained by inoculating the soil into solutions in the usual way, unless in the case of soils which are naturally very wet, offering practically the conditions obtaining in a solution. If negative results are had from solution tests, it may well be, as is the case of certain soils of this locality, that a type of nitrifying organism or composite of organisms is present which is capable of nitrifying in soils, but not in solutions; and that though the result is of negative indication, the soil may in reality be a vigorous nitrifier.

If positive results are had, it may be that the soil contains an organism similar to the sewer organisms experimented with, which ni-

trified more vigorously in solutions than in soils, and that while the indication given by the test is of vigorous nitrifying power, the soil may in reality be of low nitrifying power.

Tests by the method of liquid cultures are not of value even for purposes of comparing the nitrifying power of two soils, since two soils may nitrify to different degrees and yet both give negative results in solutions, or one bearing a vigorous soil-nitrifier may give a negative result, and another bearing a vigorous solution-nitrifier, though weak as a soil-nitrifier, may give a strong, positive result.

It seems, then, that to gain a useful indication of the nitrifying vigor of a soil, the soil itself must be used as a medium. To picture conditions as they are in the field, the field conditions must be approximated as nearly as possible. With varying soil compositions, temperature, light and water relation and a bacterial flora varying in species and vigor, the conditions are very complex and no laboratory tests can ever entirely represent them. It must, however, be the aim of the Soil Bacteriologist to approach as nearly as possible the ideal. *One imperative step is the testing of the activities of soil bacteria in soils rather than in solutions.*

Summary.

(1) Many soils which can nitrify ammonium sulphate and cottonseed meal mixed with them, fail to nitrify ammonium sulphate and cottonseed meal when used as the inoculum for solutions, such as those of Omelianski, Wiley, and Ashby.

(2) Nitrification is *nil* or very slight in saturated soils.

(3) Nitrification in some soils proceeds as fast as ammonification, converting the ammonia to nitrate as fast as it is rendered available by the ammonifying organisms.

(4) Nitrification in extract of soil is, in some instances, very slight as compared with nitrification in the soil itself.

(5) Nitrification in soils increases in intensity with the amount of inoculum used.

(6) Some nitrifying soils do not nitrify when placed in solutions even though a very large inoculum is used.

(7) Nitrifying organisms from sewer beds nitrified better in solutions than in soils.

(8) Tests in solutions are not adequate to indicate the nitrifying vigor of a soil.

THE COLORIMETRIC DETERMINATION OF NITRATES IN SOIL SOLUTIONS CONTAINING ORGANIC MATTER.

By W. A. SYME.

The accurate determination of nitrates in soil solutions by the colorimetric method with phenoldisulphonic acid and ammonia is a matter of some difficulty on account of the large number of interfering substances which may be present in the solution. Chlorides may cause a loss of nitric acid when the phenoldisulphonic acid is added to the residue left on evaporation. Iron salts affect the color. Nitrites interfere by producing a yellow color with the reagents like that caused by nitrates. These disturbing factors can be removed to a considerable extent—the chlorides by adding silver sulphate, the iron salts with sodium carbonate, and the nitrites may be determined separately by the Griess method.

The presence of organic matter in the soil extract causes trouble in several ways. In the first place, the solution may be so intensely colored that it can not readily be decolorized with carbon black; secondly, the organic matter may reduce the nitrates, thereby causing a loss of nitric acid; and thirdly, the strong acid acting on the organic matter produces substances of foreign color which can not be matched by the pure nitrate standards.

The object of the work reported in this paper was to see if potassium permanganate could be used to remove organic matter from soil extracts. The extracts were prepared for some work on nitrification now in progress in this laboratory, the method of preparation being as follows: 400 grams of soil were shaken four hours with 1,200 cc. of water containing a little chloroform. The solutions were filtered through a porcelain tube.[1] The filtrates were strongly colored when the soils contained much organic matter. The solution from soil 1867, a soil from a compost heap and the one most favorable for the nitrification experiments, was very rich in organic matter and could not be satisfactorily clarified by shaking with carbon black. When this solution was evaporated to dryness, the residue treated with phenoldisulphonic acid and made alkaline with ammonia, the resulting solution had a brownish yellow color quite different from the clear lemon-yellow given by a pure nitrate solution.

The method for treating this solution, and others of the same kind, was as follows: Heat 50 cc., or any convenient portion to 60-70 degrees, and add 1 cc. of dilute sulphuric acid (1:5). Add from a burette a dilute solution of potassium permanganate (5 to 10 gm. per liter) until in excess and heat fifteen minutes on a water-bath, adding more permanganate from time to time, if necessary to have an excess. Remove the brown precipitate by filtering into an evaporating dish, make the filtrate slightly alkaline with sodium carbonate and evaporate to dryness on the water-bath. Add water to the resi-

[1] Bulletin 31, Bureau of Soils, p. 12.

due and filter into a 50 cc. flask, wash the residue on the filter, and dilute to the mark. We now have 50 cc. of a colorless soil solution nearly free from organic matter. Nitrates can now be determined by the usual colorimetric method, remembering that if nitrite were present in the original solution, it would be oxidized to nitrate.

If a soil solution, after treatment in the way described, is evaporated and the color, developed in the usual way, is compared with that given by a portion of the same solution not so treated, the difference is very marked.

The evaporation of the soil solution with sodium carbonate removes manganese and iron, but enough nitrous acid may be taken up from the air to give an appreciable color with the nitrite reagent.

Carbonaceous matter was not entirely removed by the treatment with permanganate, though the coloring matter was destroyed and the residue left on evaporating the solution to dryness on the water-bath was colorless. The quantity of carbonaceous matter left by the permanganate was not enough to cause serious trouble when the phenoldisulphonic acid was added. The effect of the permanganate treatment can be readily seen by evaporating equal volumes of the same soil solution with and without permanganate and comparing the residues as to color, quantity of organic matter and behavior on ignition.

The method was tested by having an associate to prepare a number of solutions by adding known quantities of nitrate to soil extracts containing organic matter and giving them to the writer for analysis. The results were satisfactory in every case, and the method is now used in this laboratory.

Experiments were made to find out whether nitrate is formed by the oxidation of the organic matter by the permanganate. Soil extract 1931, containing organic matter but no nitrate or nitrite, was treated with permanganate. No nitrate was found after the treatment. A trace of nitrite from the air was found after evaporating the alkaline solution, but none was found in the acid solution before evaporation.

A liter of a colored soil extract was heated and acidified, permanganate was added in excess to the hot solution and the brown precipitate was filtered off. The filtrate was made alkaline with sodium carbonate, divided into two parts, and evaporated. In one part, nitrogen was determined by the Kjeldahl method, and in the other part by the Kjeldahl method modified to include nitrates. The same quantity of nitrogen was found in the two portions, showing that there had been no nitrate formation. This experiment was repeated with a pasture soil containing 50 per cent volatile matter, chiefly in the form of cow manure and vegetable mould. The result was the same, namely, there was no nitrate formation from the action of the oxidizing agent on the organic matter. It is therefore safe to use permanganate for the purification of soil extracts for the nitrate determination.

NOTES ON PLANT DISEASES OCCURRING IN NORTH CAROLINA.

By F. L. STEVENS and J. G. HALL.

ALFALFA.

Leaf Spot (*Ascochyta medicaginis* Bres).—This disease was found in abundance and did considerable damage in fields in Wake County. It has not been reported in America before, and is a new parasite upon alfalfa.

APPLE.

Bitter Rot (*Gleosporium fructigenum* Berk).—This disease was reported from Buncombe, Haywood, Stokes and Wilkes counties. The amount of damage is estimated at from twenty to seventy-five per cent of the crop.

Black Rot (*Sphœropsis Malorum* Peck).—Specimens of this disease were received for determination and advice from Sampson County.

Black Rot Canker (*Sphœropsis Malorum* Peck).—Apple twigs were received from Paul Cable, of Greensboro, with a statement that his trees were very seriously affected, some of them killed. Microscopic examination revealed only the presence of *Sphœropsis Malorum,* but this in considerable abundance. Apple twigs affected with the Black Rot Canker were also received from Mr. Howard, Salemburg, with a statement that they were from a young orchard of one hundred and ninety trees, twenty-six of these trees being seriously affected with this canker, one dead, and four or five others nearly dead. Another package was from an older orchard of sixty trees, in which some three of the young trees were affected and four or five of the older trees.

The canker differed from any other canker which has come under our observation, the chief point being an intense black color over the bark, and the presence of abundant spore-bearing pustules. The diseased portion is usually divided from the healthy by a sharp, definite line, and the diseased portion stopping in growth before the healthy above and below it, is nearly always of smaller diameter, giving striking appearance of constriction. On cutting into the wood of the diseased region, it was found to be blackened, often to the center, and this blackening frequently extended a long distance, both above and below the cankered portion. Microscopic examination showed this blackening to be due to the presence of a black mycelium in the diseased tissue, this mycelium having all the characteristics of that of *Sphœropsis.* On some of the cankers *Sphœropsis* only was found; on other cankers, an ascomycetous fungus only, while in other instances both the Ascomycete and *Sphœropsis* were present.

Blotch (*Phyllosticta*).[1]—For several years this disease has been noticed in many portions of the State, on apple twigs, forming small cankers. The fungus appears to be identical with that described as the "blotch," so abundant and destructive in Arkansas on the fruit and foliage of the apple. Strange to say, however, in North Carolina our attention was not called to this fungus affecting fruit and leaves until March 3, 1908. A letter was then received from M. L. Willard, of High Point, in which he states: "I wish to consult you about my apple trees. They look thrifty and bear well; about the middle of July they begin to shed some of their leaves; about the same time I discover little black specks on the apples. About the middle of August they begin shedding their leaves again, and by that time the black specks have grown till the apple is about decayed. By the middle of September the leaves are all off. By that time you hardly find an apple but what is decayed or partly decayed. The trees I am speaking of are the Red Limbertwig. I have in the same orchard some May apples and some harvest apples that mature well."

Fig. 1.—Apple Canker, Pyllosticta. At right, one year old twig showing several young cankers; at left, older twig showing more mature and rougher canker.

From this description it seems probable that this is an actual occurrence of the blotch in a very destructive form on the fruit in North Carolina.

Canker (*Phyllosticta*).—The canker upon the bark of apple twigs has been under observation for several years. It usually begins upon the one year old twigs, where the canker first appears as yellowish, brown spots, in the central region of which are scattered very minute spore bearing pustules. As the canker becomes older, it encroaches upon the fresh bark around the original canker; the bark ruptures and a considerable portion becomes roughened. The spores from the pycnidia show the fungus to belong to the genus *Phoma* or the genus *Phyllosticta*.

[1]This is the species reported by some pathologists as P. *solitaria* E. and E.

It is unquestionably the fungus called *Phyllosticta solitaria* by various authors, and which has been reported as being extensively destructive upon the fruit of the apple in several States, notably in Arkansas. It is noteworthy that so far as our observations go, this fungus, while widely distributed upon the twigs, does little or no damage upon the fruit itself here unless in exceptional cases.

Aside from finding this canker abundant in Wake County, specimens were also received from Madison and Henderson counties.

Fireblight (*Bacillus amylovorus* (Bur), De Toni).—This disease was noted in a very destructive form in nearly all of the counties visited on the Farmers' Institute trip. In many instances single trees were killed; in some instances, whole orchards. Specimens were received during the year from Iredell, Buncombe and Sampson counties.

Hypochnose.—This disease, not heretofore recognized in the United States, was collected in the following places in North Carolina: Horseshoe, Addie, Franklin, Hayesville, Marshall, Murphy, Robbinsville, Sylva, Bryson City, Fatima, Newton, Eufola and Mt. Airy. It produces a rotting of the leaves, in which condition they have a tendency to droop and mat together. These diseased leaves are accompanied by brown, fibrous or globular sclerotial formation upon the twigs.

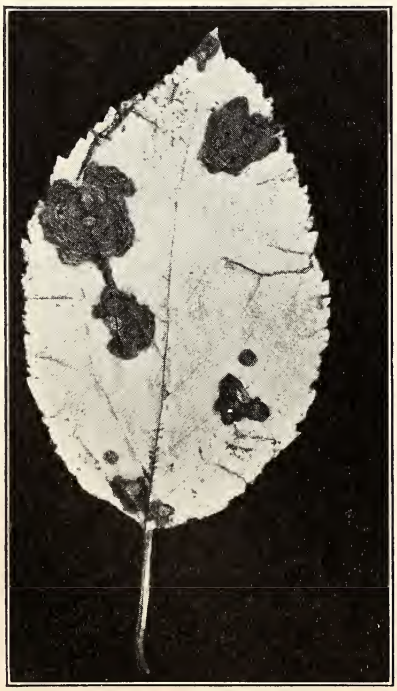


Fig. 2.—Apple Leaf Spot, in late stage of development, showing concentric rings.

Leaf Spot (*Phyllosticta, sp.*).—Leaf spots, consisting of brown dead tissue, occur in all portions of the State. It is customary to attribute these spots to a species of *Phyllosticta.* Whether they are all due to the same species, or indeed whether they are all due to *Phyllosticta* at all or not is an open question. In any even, the leaf spot abounds in North Carolina wherever the apple is grown, being, in general, very much worse in the mountains than in the more eastern sections of the State. The leaf spot consists of circular regions of dead tissue, sharply bounded from the healthy tissue. In the older spots there is a characteristic concentric arrangement of irregular circles. This disease is al-

most entirely held in check by proper spraying. Specimens were received from the following counties: Rowan, Guilford, Davidson, Vance, McDowell, Greene, Burke, Iredell, Wake, Henderson and Surry.

Moniliose (*Monilia fructigena* Pers.).—This fungus was found upon apples sent to the Station by B. F. Sparger, of Mount Airy, many of the fruits submitted by him developing well marked, characteristic cases of *Monilia* rot after remaining in the laboratory for a few days. The fungus, from measurements and appearance, agrees entirely with *Monilia fructigena*. This is the first record of the occurrence of this disease in North Carolina, although it has long been seriously destructive in Europe. It has been reported from the following States: Arkansas, Nebraska, New Mexico, Virginia, and West Virginia. The disease was particularly abundant in the portion of the orchard adjacent to plum orchards, where the Japanese and Abundance plums had been very seriously affected with this fungus the preceding spring.

Rust (*Gymnosporangium, sp.*).—The apple rust is much worse in the Piedmont and the coastal section than in the mountains. It was seen in an especially destructive form this year in Brunswick and Durham counties. Specimens were submitted this year from the following counties: Franklin, Wake, Halifax, McDowell, Burke, Rowan, Iredell, Cabarrus, Mecklenburg and Surry. Its winter stage upon the cedar tree is a familiar sight in spring, throughout the eastern and central portions of the State, most of the cedar trees being thickly hung with cedar balls, protruding from which are the well-known gelatinous honey-colored horns. This disease is said to be more severe upon the Tawny and the Horse apples.

Scab (*Venturia inæqualis* (Cke.), Wint).—Specimens of this disease upon the fruit and also upon the leaves where it appears as black, sooty spots, were received this year for determination from Buncombe, Iredell and Moore counties.

BEANS.

Anthracnose (*Colletotrichum Lindemuthianum* (Sac. & Magn.), Bri. & Cav.).—This anthracnose occurred in considerable quantity on the College farm and other places in Wake county. Reports were received from Montgomery and Iredell counties. One report says that 90 per cent of the pods were diseased. In October a large quantity of diseased pods was gathered, brought to the laboratory and dried, for the purpose of study.

Rust (*Uromyces appendiculatus* (P) Lav.) was collected in Davidson and Catawba counties.

CANTALOUPES.

Downy Mildew (*Peronospora Cubensis* B. & C.).—This disease is identical with the mildew of the cucumber and may be expected anywhere that the cucumber disease is found.

Nematodes (*Heterodera radicicola* (Greef), Mul.).—Specimens of cantaloupes very badly galled by nematodes were received in September from R. A. Parker, Duplin County. The roots were galled from end to end, the galls being exceedingly large and abundant. Referring to the injury done, he says: "We planted five acres. They came up and grew off at first better than my neighbor's in an adjoining field, but about the time they began to run they began to turn yellow, and lots of them finally died. A good many that did not die did not produce any fruit. We gathered 500 crates from the five acres and my neighbor in adjoining field gathered 600 crates from three acres." Specimens of roots from the "adjoining field," mentioned above, proved to be entirely free from nematodes, and it is probable that the discrepancy in yield between these two fields is to be attributed to these nematodes. The disease is apparently very widely distributed through the State, often doing much damage.

CARNATION.

Root Knot (*Heterodera radicicola* (Greef), Mul.).—Roots affected with nematode galls were sent to the Station for determination from Wake county.

CAULIFLOWER.

Black Rot (*Pseudomonas campestris* (Pam), Smith).—Specimens of cauliflower thickly covered with densely black spots were observed upon the open market in Raleigh. The disease was exceedingly conspicuous, owing to the intense black spots upon the white background furnished by the healthy portions of the cauliflower. Upon examination it was found that the black spots were due to bacteria, which had all the appearance of being the usual form causing the black rot of the cabbage. The vascular bundles, leading from the spots toward the center of the head,

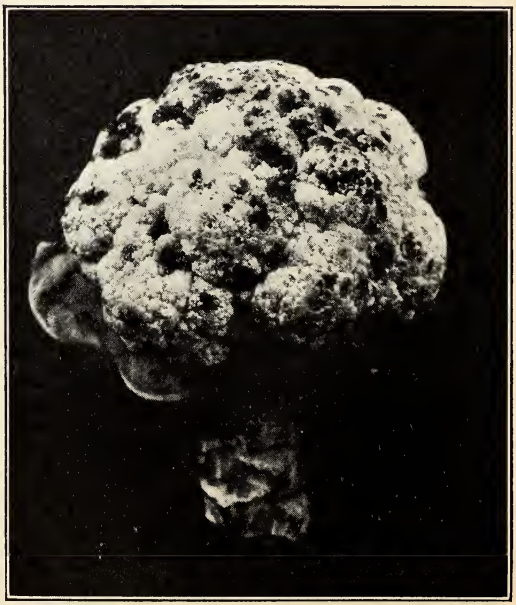


Fig. 3.—Cauliflower Black Rot (Pseudomonas campestris). The blackened spots are caused by this bacterial rot.

were blackened in a manner characteristic of vascular bundles of plants affected with black rot, and it seems clear that this disease is identical with the cabbage black rot.

From the appearance of the disease it seems certain that the infection was from the surface and the disease was progressing inward. Upon inquiry, it was found that the diseased cauliflower was shipped from Washington, N. C., and it was impossible to ascertain where they were grown. The occurrence of this disease in this fashion is of much interest to North Carolinians, since it shows one manner in which it may gain access into and distribution through the State.

CELERY.

Leaf Spot (*Septoria petroselina* Desm. var. *apii* Br. & Cav.).—This disease made its appearance in a very destructive form in gardens in Wake county this year, causing the loss of the whole crop in many instances. The leaves turn yellow, and then, upon closer examination, are found to have black dots, pycnidia, upon them. This disease may be held in check by spraying with Bordeaux mixture.

CHRYSANTHEMUM.

Leaf Spot (*Septoria Chrysanthemi* Cav.).—This diseased specimen was sent in for determination from Cumberland county.

CHERRY.

Shot Hole Disease (*Cylindrosporium padi* Karst).—This disease abounds in all sections of the State. It was collected particularly this year in Brunswick, Wake and Halifax counties, and specimens were sent in for determination from Guilford county.

COLLARDS.

Sclerotinose (*Sclerotina Libertiana* Fckl.).—Collards affected with this disease were collected in Wake county by B. B. Higgins.

COTTON.

Anthracnose (*Colletotrichum gossypii* South).—Cotton anthracnose has been particularly abundant this year. Specimens were received from Cleveland, Wake, Craven, Montgomery, Beaufort, Iredell counties, and letters of inquiry concerning it were received from Richmond and Scotland counties. In many instances people writing concerning cotton anthracnose in their fields this year stated that the only portions affected upon their plantations were fields which were planted with seed from some distant source, it being frequently stated that the seed producing the anthracnosed crop came from Georgia. The frequency with which such observations were made agrees well with the generally accepted idea that the fungus causing the anthracnose may be carried from one crop to the next upon the seed, and it serves to emphasize the importance of avoiding seed which

comes from infected fields, and of knowing the character of the field from which seed does come, so that the grower may be certain that the seed which he has purchased came from a healthy, not from a sick field.

Aerolate Mildew (*Ramularia areola* Atk.).—The frosty mildew affects the leaves, producing small, angular spots, which are first pale green, then turning light yellow and pale brown. Upon the under side of the leaf, in the early stages of this disease, small spots covered with a frosty white growth are seen. The disease is seen in most cotton fields examined, but usually it is of no very great importance, although in some instances, if the leaves become much spotted, the whole leaf will become weakened, will turn yellow and fall off. In this way the disease sometimes becomes to some degree serious.

Bacterial Disease (*Bacillus Malvacearum* Erw. Smith).—Specimens of this disease were collected in Wake county. The disease was not noticeable in particularly destructive form. In seriousness it seems to be about equal to the frosty mildew, which in many ways it very closely resembles in general appearance.

Wilt (*Neocosmospora vasinfecta* (Atk.), Erw. Smith).—Several complaints of cotton wilt from isolated sections of the State were received this year. This disease is undoubtedly widespread throughout the cotton section of the State, although in many instances the territory of the individual fields which are invaded is not very large. The disease, however, is constantly spreading, and is one which should be carefully guarded against by cotton growers.

COWPEA.

Leaf Blight (*Cercospora Dolichi* E. and E.).—This leaf blight prevails nearly everywhere the cowpea grows, producing a spot which, viewed from below, is angular and is of a uniform ashen, dirty color. The spot is surrounded by a region of the leaf, which is pale yellow in color. Many spots upon the leaf result in its premature death and cause it to fall off.

Leaf Spot (*Amerosporium œconomicum* E. & T.).—This disease is readily distinguished from the last by the fact that the spots are circular and are studded all over with little black specks smaller than the ordinary pin hole. The spots of this are also of shining whiteness, and in this character are quite readily distinguished from the Cercospora spot. The disease is often abundant, but is usually not so serious as is the Cercospora.

Root Knot (*Heterodera radicicola* (Greef), Mul.).—Plants badly affected with root knot were collected in Wake county. This disease may be overcome by using the Iron variety of cowpeas, which is resistant to the disease.

FIG. 4.—Cowpea, Leaf Spot (Amerosporium).

FIG. 5.—Cowpea Leaf Spot (Amerosporium). Abundant spore bearing pustules scattered throughout the circular spot (enlarged four diameters).

CUCUMBER.

Downy Mildew (*Peronospora Cubensis* B. & C.).—The downy mildew, which has proved so destructive to cucumbers in other States, in South Carolina so injurious as to almost destroy the cucumber industry in certain sections, has begun to make its appearance abundantly in North Carolina. Specimens were collected this summer in Wake, Wayne, Cabarrus and Alamance counties. This disease is recognized by the yellowish angular spots as shown from the upper side of the leaf. The spots enlarge until the whole leaf is involved, and it soon droops and dies. This disease has given way in other States to careful spraying, and would probably do so here.

DEWBERRIES.

Septoria rubi West.—Specimens were received for determination from Moore county.

GRAPES.

Black Rot (*Guignardia bidwillii* (Ell.), V. & R.).—This disease is abundant throughout all portions of the State and upon all varieties of bunch grapes. The scuppernong is almost immune and is only rarely found with a single spot of black rot. Specimens of black rot on the bunch grape were received from Buncombe, Halifax, Pender, Burke and Moore counties.

GRASS.

Myxomycete (*Physarum cinercum* (Batsch), Pers.).—In several instances grass has been known to be affected with a species of Myxomycete. The fungus causing this damage has been determined by McBride as *Physarum cinereum*. The damage begins in the diseased spots in the lawn or field, in which the grass plants become totally covered with the fruiting organs of the fungus, so that when viewed from a distance of a few feet nothing but a black spot is seen, the grass being entirely hidden by the slime mold growing over it. The spot rapidly enlarges, often becoming several yards in area. This disease was noted a year ago at Raleigh, and it became so serious at Waynesville and Oxford that specimens were sent in for determination and advice this year. It may be mentioned that the same fungus has also been noticed as a parasite on grass in Montgomery county, Penn.[1]

LETTUCE.

Sclerotinose (*Sclerotina Libertiana* Fckl.).—This fungus made its appearance upon the lettuce beds of West Raleigh, where it was first seen by B. B. Higgins on November 26. The sick plants collected and brought into the laboratory developed the characteristic symptoms of sclerotinose. There is no record that this fungus existed in this place before, and its occurrence is noteworthy as a possible

[1] A Grass-killing Slime Mould. By John W. Harshberger, Ph D., Proc. Am. Phil. Soc. XLV, Nov. 3, 1906.

indication that the fungus was already in the soil, subsisting naturally on some other host plant.

PEACH AND PLUM.

Cornularia Persicæ (Schw.), Sacc.—This peculiar fungus was noted in every portion of the State where examination for it was made. Specimens were collected in abundance in Wake and Lenoir counties. It probably does little or no damage to the trees.

Peach Curl (*Exoascus deformus* (Berk.), Fckl.).—Specimens were received for determination from Granville county. This disease is almost completely controlled by spraying with Bordeaux mixture before the buds open.

PEAR.

Black Rot Canker (*Sphæropsis malorum* Pk.).—Specimens of badly cankered pear limbs were received from S. C. Godwin, Fayetteville, on December 13. Microscopic examination showed the presence of mycelium and fruiting pycnidia of *Sphæropsis* in great abundance. Godwin writes: "Some of my trees are dead and all except one are so badly affected that they can hardly survive."

This is the first complaint that we have had of *Sphæropsis* as a very destructive canker-producing fungus on pears in this State, although the fungus is exceedingly common upon the apple. Specimens showing injury from this disease were also received from Cumberland and Alexander counties.

Blight (*Bacillus amylovorous* (Burr.), De Toni).—This blight was even more destructive than the apple blight, as is usually the case, and is present in the State practically everywhere that pears are grown, and upon nearly all varieties. One variety, known as the Florida Sand Pear, raised by N. W. Herring, LaGrange, N. C., possesses a very high degree of resistance to this disease. On inspection last year this variety was seen to pass entirely unscathed, while adjoining Keiffers were very seriously affected. Specimens were received from Mecklenburg, Jackson, Randolph and Moore, and inquiries from Catawba, Franklin, Richmond and Vance counties.

Leaf Spot (*Septoria piricola* Desm.).—Pear trees badly infected with the leaf spot were noted in Brunswick county, about twenty miles from Wilmington, in the summer of 1907. The trees were so badly infested that every leaf bore one or more spots, while many of the leaves had a dozen or more each. The spot was exceedingly characteristic, being of a pale, ashen color, with a very definitely limited border. It was angular in outline and limited by the veins. The spots were small, ranging from two or three to six or eight millimeters in diameter, and usually bore one, two or three small black specks, which upon microscopic examination proved to be pycnidia. In section, the pycnidia are seen to be deep-seated, only the mouth

projecting above the epidermis. In appearance they agreed exceedingly well with the drawing given by Atkinson in Bulletin 145 of the Cornell Experiment Station. The cavity of the pycnidium was filled with rather long, curved, crooked or crescent-shaped spores, which exhibited a strong tendency to adhere together in compact

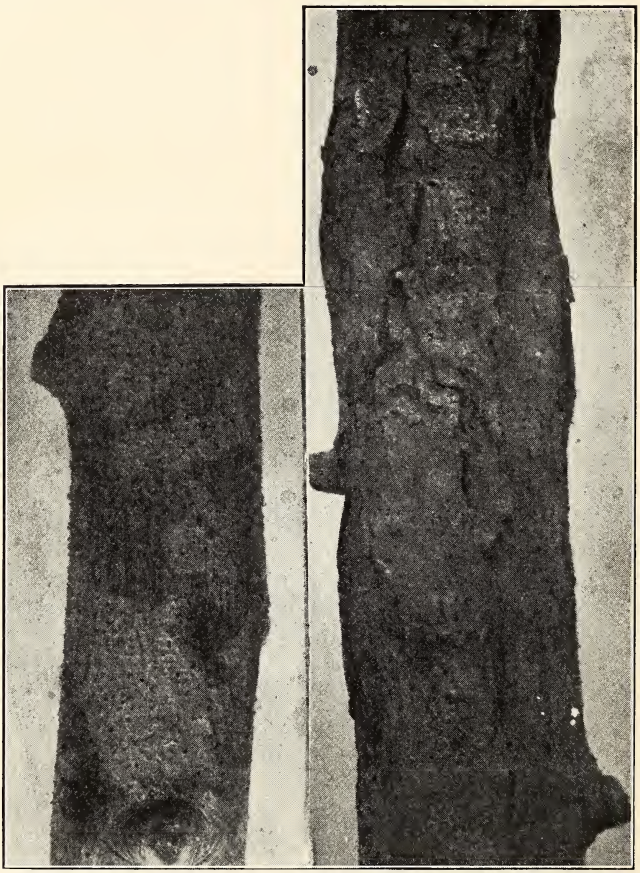


FIG. 6.—Pear Canker (Sphæropsis). At right, the cracked bark of cankered portion. Minute spore bearing pustules are apparent in certain portions. At left, bark thickly beset with spore-bearing pustules.

masses. These spores have the characteristic shape, form and septation of *Septoria*. Most of them were continuous, though very rarely spores with one, or occasionally two septa were seen. In striking distinction, however, from the usual *Septoria*, and from the genus as defined, these spores were dark in color, agreeing thereby with the genus *Hendersonia*. The possession of dark spores seems, however, to be permitted to *Septoria* in the species *Septoria piricola* Desm., which is, in all probability, the species in hand.

POTATO, IRISH.

Scab.—The prevalence of this disease in the State is not well known. It is probably abundant. Specimens were collected this year by B. B. Higgins at Newton and Eufola.

POTATO, SWEET.

Dry Rot.—A rot of the sweet potato, consisting of sunken, somewhat shriveled, dried, brownish areas, has been repeatedly reported to the Station this year for diagnosis and advice. The accompany-

Fig. 7. – Sweet Potato Dry Rot. Below is shown shrunken, shrivelled, brownish, diseased region; above is shown a longitudinal section, and the depth to which the disease penetrates.

ing illustration shows the appearance of the potato, both from surface view and in section. It is noticed that the rot penerates to considerable depth into the potato.

Observations in the laboratory show that the diseased spots enlarge slowly, as time passes, yet with sufficient rapidity to cause the spot to change from a small one to a very large one in the interim between housing and springtime.

In culture this condition of disease always gave a *Fusarium,* which was accompanied by a *Nectria,* apparently identical with *Nectria Ipomoeæ,* mentioned by Halstead[1] as causing a rot of the sweet po-

[1] N. J. Agr. Exp. Sta. Rept., 1891, p. 281.

tato. While the fungus seems to be the same one noted by Halstead, we do not feel sure that the rot with which we are dealing is the disease which he studied.

Specimens of potatoes affected with this disease were received from L. C. Ellington, Madison county, January 8, 1908; J. M. Garrison, Gaston county, and A. B. Cooper, Beaufort county.

The relation of the fungus to the disease is still the subject of study here. The indications at present are that this is a soil disease and that it is not advisable to raise potatoes successively on fields where this disease has shown itself.

Leaf Spot (*Phyllosticta bataticola* Ell. & Mart.).—The *Phyllosticta* spot is present in sweet potato fields generally, but it is probably not of serious import.

White Smut (*Albugo Ipomoeæ panduranæ* (Schw.).—This is found frequently, though it is not exceedingly common upon the sweet potato. The injury from it is trifling.

QUINCE.

Rust (*Gymnosporangium*).—This rust, the same that affects the apple, winters likewise upon the cedar tree. Specimens were received for determination from Moore county.

ROSE.

Black Spot (*Actinonema rosæ* (Lib.), Fr.).—Specimens were received from Warren county.

Blossom Blight.—Attention has been repeatedly called to a disease of roses, which appears in very destructive form. The disease manifests itself in the failure of the buds to open. The buds mature in apparently normal condition, until they become about one inch long, the outer petals then show signs of wrinkling, the first indication of the disease. The buds continue to expand somewhat, the outer petals begin to turn yellow or straw-colored, and soon all development ceases. In some instances the buds partially open, but as a rule they do not attain a size of more than $1\frac{1}{2}$ inches, and the petals do not really open at all. In most instances where the disease is noted it occurs on several buds on the bush. The character of the disease in single buds is shown in Fig. 9.

In a short time after the disease becomes evident in the bud, all development ceases, petals die, and the line of absission between the pedicil and the stem becomes marked, and the flower may be easily separated from its stem at this point. The whole bud soon dries up, its stem, down to the line of absission, likewise shrivels and dries, and the occurrence of the disease remains conspicuous by the presence of dry, straw-colored, dead buds upon the bush.

The disease is known to recur season after season on the same bush, while other bushes in the immediate vicinity, growing in the same soil and climate, are free from infection.

Close microscopic examination failed to reveal the association of any fungi or bacteria with this disease. It seems, therefore, that it must be, for the present, classed as a "physiological disorder," brought about by some unknown cause. It is possible that it is hereditary and that avoidance of stock subject to this disease may lead to the removal of the difficulty.

FIG. 8.—Rosebud Blight, showing destructive nature of the disease on individual bushes; every bud is diseased.

FIG 9.—Rosebud Blight, showing withered bud and dry, dead condition of the peduncles.

MILDEW (*Sphærotheca pannosa* (Wallr.), Lev.).—This disease is one concerning which probably more queries have been received than regarding any other plant disease of the State. The Mildew makes its appearance early in the spring, almost as soon as the leaves come out, as a white, dusty powder over the surface of the leaves, stems and buds.

The leaves so affected fail to develop properly, roll or curl up, the buds fail to open, and the growth of the plant is stunted. The appearance of such a diseased twig, as contrasted with the healthy twig, is well illustrated in Fig. 10. Concerning this disease this year, queries and specimens have been received from the following counties: Halifax, Cleveland, Durham, Warren, Iredell and Granville counties. Queries without specimens were received from Chowan county.

The rose mildew may be readily prevented or held in check by use of the various spraying mixtures. Probably the Bordeaux mixture

b a

FIG. 10.—Rose Mildew: (a) healthy twig; (b) badly diseased twig.

is most to be recommended, unless the bush is so located that the use of the Bordeaux mixture would be undesirable, such as would be the case, for example, if the rose bush grows near a white house in such position that the Bordeaux would spot the house in an unsightly way. In such event, either liver of sulphur, one ounce in three gallons of water, or the ammoniacal copper carbonate may be substituted.

SORGHUM.

SMUT (*Sphacelotheca sorghi* (Link), Clint.).—A smut attacking the flowers and fruit, but not the stalk or leaves, was found in Wake county, but not in such quantities as to be of any serious damage.

SQUASH.

(*Fusarium*, sp.).—Garden squash were seriously diseased in some instances, the vines appearing stunted, pale, and later dying. Upon miscropic examination, the vascular bundles were seen to be invaded by a fungus, which proved to be a species of *Fusarium*. The disease had all the characteristics of the ordinary wilt and was apparently caused by this fungus, which is one of the most common of the wilt-producing fungi. Whether the fungus be identical with that causing the wilt of cotton, melons, etc., was not determined, though no differences were noted.

SYCAMORE.

Powdery Mildew.—A powdery mildew has been noticed affecting the leaves of the sycamore seriously in early spring. Leaves are attacked long before they reach the mature form and structure, presenting very much the appearance of frost injury. The affected spots are blighted, fail to grow, turn dark in color. Owing to their failure to grow, the leaf becomes wrinkled, curled, and distorted. Examination of the affected spots shows them to be densely overgrown with the conidial stage of a powdery mildew. While no mature fruiting organs have been found, and it is impossible to make a complete determination of the fungus in its conidial stage, it agrees entirely with the description of *Microsphæra Alni*, which is reported as growing upon this host. The fungus is especially noteworthy from its attack early in the season upon leaves before they have completed their development.

TOBACCO.

Frog Eye (*Cercospora Nicotianæ* E. and E.).—Specimens were collected in tobacco barns at Greenville. The disease is probably generally prevalent.

Granville Tobacco Wilt.—This disease, hitherto unknown in literature outside of Granville county, was noted this year in Durham and Vance counties, and specimens, which seemed almost certainly to be this disease, were received from Quincy, Fla., where, says Shamel, "they are doing immense damage."

At Graystone, N. C., July 22, on the farm of James A. Tunstall, Ashe county, two small fields were noted where the wilt occurred. In one instance, out of six hundred plants counted, two hundred showed the typical disease, and it was apparent that about the same percentage prevailed throughout the field. Mr. Tunstall stated that he had known this disease in his tobacco for more than twenty-five years, and has been obliged to abandon a great deal of his tobacco land on account of its occurrence. According to his experience, the land affected with the wilt, left without tobacco for ten years, is still diseased, and if planted again at the end of that time, with tobacco, results in the loss of a large percentage of the crop.

One farmer in the neighborhood lost his entire crop through this disease. There came under our personal observation one field of which it was stated that tobacco had not been planted on that field for at least twenty-five years, the field, however, was very badly wilted.

Root Knot (*Heterodera radicicola* (Greef), Mul.).—Many complaints were received concerning the root galls upon tobacco; notably from Whiteville and Washington. These galls are caused by minute worms or nematodes similar to the vinegar eel. These worms abound in the soil and from it enter the roots of the plants and cause the gall to develop. In many instances they do not seem to cause serious loss, but in other instances they are very destructive to the crop. The only remedy is to so rotate the crops as to avoid planting susceptible crops upon soil bearing nematodes.

There is always a possibility of finding tobacco plants which possess a resistance to the worms. If such plants are noticed, seed from them should be saved with great care with the hope of building up a disease-resistant variety.

TOMATO.

Blight (*Bacillus Solanacearum* Erw. Smith).—This bacterial disease of the soil which causes a dying of all tomatoes placed in it, unfortunately claims many fields of the State, and it is constantly spreading into new territory. It was noted in its usual abundance this year.

Blossom End Rot (*Fusarium Solani* (Mart.), Saac.).—Specimens were received for determination from Pamlico county.

Leaf Spot (*Septoria Lycopersici* Speg.).—The *Septoria* is to be distinguished from the blight by the fact that the leaves when first infected are diseased in spots only, whereas, in the blight the leaf is not spotted, but droops and dies as a whole. The leaf spot usually affects the lower older leaves first. As the spots enlarge, encroaching upon the whole leaf, the leaf dies. Often the disease progresses so fast that the whole plant soon becomes involved. This disease may be controlled by spraying with the Bordeaux mixture.

VETCH.

Downy Mildew (*Peronospora viciæ* (B.), DeBy.).—This disease appeared upon cultivated vetch in Wake county this spring and did a great deal of damage. The plants affected did not develop normally, were much smaller, weaker and paler than the neighboring ones. Upon close examination the under side of the leaves was found to be covered with the fine down of *Peronospora.*

WATERMELON.

Wilt (*Neocosmospora vasinfecta var nivea* Erw. Smith).—Inquiries concerning this were received from Vance county.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

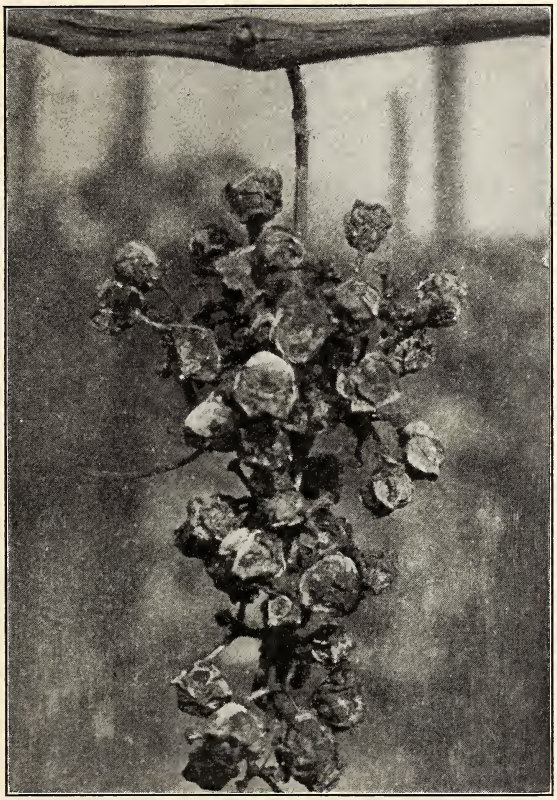
C. B. WILLIAMS, Director.

PRESS BULLETIN No. 17.—FEBRUARY 15, 1908.

THE GRAPE BLACK ROT.

This disease prevails in all parts of North Carolina. In most sections of the State it is so bad that the grape crop is practically ruined unless proper measures be taken to prevent the disease.

The black rot is easily recognized from the accompanying illustration showing its most conspicuous characters, blackening, drying



and final shrivelling of the grapes in the clusters. Often all of them shrivel and dry in this way. Though the disease is seldom noticed until the grape is badly shrivelled, it may be seen earlier as a brown or black spot on the berry. Before its appearance upon the fruit at

all it may be found as brown spots, one-eighth to one-half an inch in diameter, on the leaves or twigs. Very close examination of the diseased spots on twigs, leaves or fruit, reveals the presence of very small pustules in great numbers.

These pustules are the fruiting bodies of the fungus which is the cause of the black rot, and from these pustules issue immense numbers of spores, which serve to spread the disease.

This disease can be prevented. If you saw black rot on your grapes last year it will almost certainly be there again this year, unless you take steps to prevent it. Prevention is simple and sure. It consists in spraying your vines with the Bordeaux mixture, consisting of six pounds of bluestone, four pounds of lime and fifty gallons of water. The first application, killing the spores that are wintering on the bark and trellis, should be made before the buds open; the second, immediately before the blossoms appear; the third, just after blossoming; the fourth and fifth at intervals of ten to fourteen days thereafter.

The cost of six sprayings for an acre of grapes is about fifteen dollars, including material and labor. The grapes saved will in value far exceed this cost.

Now is the time of year to get your spray pump ready if you have one; to buy one if you need to; to prepare for the spraying needed during the coming spring.

If you need further information regarding spraying mixtures, how to prepare them, spraying pumps, where to buy them, and what crops and when to spray, write to the North Carolina Agricultural Experiment Station, West Raleigh, N. C., for Bulletin 193, "Spraying Mixtures and Machinery, When and How to Spray."

The following Bulletins of interest to fruit growers may be secured upon application:

Bulletin 184. Garden and Orchard Fruits, their Culture and Marketing.

Bulletin 185. Black Rot of the Grape in North Carolina and Its Treatment.

Bulletin 186. Insect and Fungous Enemies of the Peach, Plum, Cherry, Fig and Persimmon.

Bulletin 187. Grapes and Small Fruits.

F. L. Stevens, *Biologist.*

Bulletin 197 MAY, 1908

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND

MECHANIC ARTS

WEST RALEIGH

SOME INSECT ENEMIES OF GARDEN CROPS

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

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Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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SOME INSECT ENEMIES OF GARDEN CROPS

CONTAINING PRACTICAL INFORMATION CONCERNING THE HABITS AND LIFE HISTORIES OF CERTAIN INSECTS, WITH REMEDIAL SUGGESTIONS

By R. I. SMITH, Entomologist

Without the home garden the farm is incomplete. Even the town or city home with its small area of land should possess a garden in which many vegetables may be grown to help supply the table, and reduce the market and grocery bills during both summer and winter. It often happens that the pleasure and profit derivable from the possession of a garden are both greatly diminished by the insects that prey upon the various vegetables, and sometimes entirely destroy them. Far too many gardens are carefully prepared and planted and afterwards allowed to become food for various insects, mainly through ignorance on the part of the gardener of the methods by which they might be controlled. For the person who aims to sell a part of his garden products a knowledge of insects and their control is especially necessary. The question of profit or loss may depend on the suppression or non-suppression of these pests.

It is only too true that some insects are difficult or almost impossible to suppress, but the great majority are within man's control when the proper remedial and preventive measures are applied. An illustration of well known and fairly easily preventable insect injury, occurring annually, is that of the Colorado Potato Beetle, which is perhaps one of the most common. The writer has frequently met with farmers, and small garden owners, who relied solely upon hand picking for the suppression of potato beetles, and frequently even this unsatisfactory method was delayed until the plants were nearly destroyed. How much time, labor, and expense, to say nothing of actual loss, such people might have saved by dusting the potato plants with dry Paris-green mixture, or by using the same poison as a liquid spray. This method of fighting the potato beetle and similar simple, reliable remedies for other insects are discussed in subsequent pages.

Numerous illustrations are inserted to assist the reader in recognizing the insects mentioned and as an aid in understanding their life history and habits. Without some knowledge of these facts insects can not generally be fought intelligently.

In these pages no attempt has been made to include all the various insect enemies of the crops mentioned, but such only as may appear every year and cause more or less damage unless fought successfully. *"To be forewarned is to be forearmed,"* should be the maxim of every gardener. A knowledge of the life history and habits of insects aids one in adopting more successful preventive measures against these enemies.

Life History and Development of Insects.

The habits of insects constitutes a very interesting and broad field for study and investigation. Without some knowledge of the development, i. e., the life history of our principal injurious insects, we would be poorly equipped to conduct a warfare against them. It is not to be expected, nor is it necessary, that every gardener should know all about the changes undergone by these interesting insects, but there are a few principles governing their growth and habits that every person may readily remember. One of these is the *development,* or the changes that an insect undergoes during its life, and another is the *feeding habits* of all the various forms. These two principles, it will be found, are closely related, for certain insects, while in the young, immature stage, secure food by biting and chewing, like caterpillars; while the adult or parent of the same insect may take its food in an entirely different manner, for example, moths and butterflies. Grasshoppers, on the other hand, *always* chew their food, and in order to illustrate two forms of Insect Development, we will compare their growth with that of the Green Cabbage Worm.

Incomplete Metamorphosis.—Grasshoppers undergo incomplete

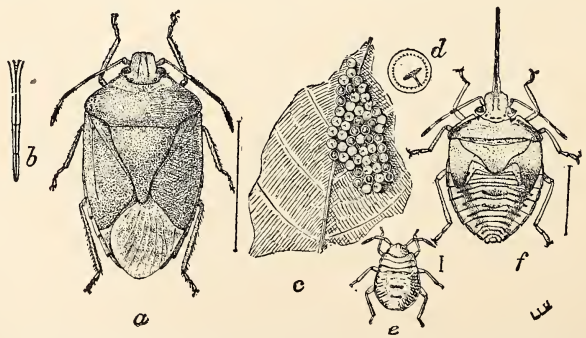

Fig. 1—Plant Bug, *Nezara hilaris: a*, mature bug; *c*, egg mass; *e*, young nymph; *f*, last stage of nymph—enlarged. (Chittenden, Farmers' Bul. 223, U. S. Dept. of Agr.)

metamorphosis or *direct development,* as there are only three distinct stages of growth, namely, *Egg, Nymph* (young), and *Adult.* Grasshopper eggs are deposited in masses in the ground, and from them, in due time, minute grasshoppers hatch, resembling the adult in

general shape but somewhat clumsy in appearance and lacking wings. As they increase in size by successive molts, the wings commence to develop, first appearing as small, blunt pads, and finally becoming full grown. During this development the grasshopper always retains its general form and appearance. That is, a young grasshopper may always be recognized as such. Fig. 1 illustrates the similar growth of a plant bug *(Nezara hilaris)*, a sucking insect that sometimes punctures and injures cotton bolls.

Complete Metamorphosis.—Cabbage worms have a markedly different life history from the grasshopper, as they pass through four distinct stages, namely, *Egg, Larva* (worm), *Pupa* (quiescent stage) and *Adult*. This is called "complete metamorphosis" or *Indirect Development*. The adult or parent of the cabbage worm is a conspicuous white-winged butterfly (See p. 21) that flies about collard and cabbage fields on any bright, warm day. These deposit eggs that hatch into minute worms, which, when grown, change to pupæ corresponding to the familiar cocoon stage of many butterflies and moths. From the pupæ the perfect, fully developed butterflies emerge. To one wholly ignorant of the growth of insects these wonderful changes might seem impossible, but the statement may easily be verified by any one caring to make the experiment. The four stages of the Bean-leaf beetle showing "complete metamorphosis" are illustrated in Fig. 6, p. 15.

A few common garden insects have direct development, the young resembling the adult, such as plant lice, terrapin bugs, squash bugs, plant bugs and grasshoppers, but by far the great majority of them have indirect development, passing from the worm, grub, or caterpillar stage, to entirely different looking forms, such as beetles, moths and butterflies. These complete changes in appearance have at times given people erroneous and ridiculous ideas about certain insects. As an example, the writer once received a letter from a farmer, stating that the plant lice had been very abundant on his cantaloupes, but that they were then changing to beetles. These proved to be lady-bird beetles, predaceous parasites feeding on the lice, and of course an entirely different kind of insect. Besides, the beetles were directly responsible for the disappearance of the injurious lice.

Common Names of Immature Insects.

Entomologists classify insects into various orders, and have adopted a few common, accepted names for the young or immature stage of certain orders. For example, *Maggots* develop into two-winged flies (Order: Diptera); *Grubs* into hard-winged beetles (Order: Coleoptera); *Caterpillars* (both smooth and hairy) into moths or butterflies (Order: Lepidoptera). These common titles are frequently made use

of by writers. Thus the reader may understand that when white grubs are mentioned it refers to the young of some beetles, generally May or June beetles. Similarly when caterpillars are mentioned the term always refers, or should refer, to the larval stage of moths or butterflies.

The term *larva* (plural spelled larvæ) may be used in referring to the young stage of all insects that have complete metamorphosis, such as beetles, bees, flies, moths, etc. The word *nymph* is used for the young of grasshoppers, terrapin bugs, squash bugs, etc., that resemble the adult insects.

Chewing and Sucking Insects.

More important in some respects than the knowledge of the life history of an insect, is that of its feeding habits. Every gardener should understand how insects get their food, whether by chewing or sucking, for without that knowledge he can not as readily understand why certain remedies are suggested against different insects. As already mentioned, the caterpillars, represented by cut-worms and cabbage worms, feed by chewing and actually devouring some portion of the host plant, while the parent moths or butterflies feed entirely differently. All beetles and their young feed by chewing. On the other hand, all plant lice, squash bugs, and most insects commonly known as "bugs," feed by means of long, slender beaks, which are used to pierce the plant tissue, and through which the plant juice is extracted.

Insects, therefore, may be divided into two great classes: first, *Chewing* or *Biting Insects*, and, second, *Sucking Insects*. The former includes all insects, whether in the immature or adult stage, that feed by biting and chewing; the latter includes a large class of insects that feed only by sucking the plant juices. A moment's thought will reveal the reason why it is that a poison spray, such as Paris-green mixture, that acts as an internal poison when swallowed with the food, would not kill an insect that sucks the sap. The latter make only a minute hole with the pointed beak and suck the sap from beneath the surface. How, then, may sucking insects be killed? Naturally by some substance that will kill by contact, having a corrosive, caustic, or suffocating effect. Kerosene emulsion, soap solutions, etc., are examples and are described more fully on pages 63 and 64.

This brief, simple statement of facts is inserted mainly as a suggestion to those readers who desire to learn something about insects. Of course arsenical poison sprays and contact sprays are useless against some insects. Borers and other forms that feed in protected places, even though they chew their food, can not be reached with

arsenicals, neither can sucking insects be killed by a contact spray unless touched by the mixture. It is customary for people to think that all garden insects may be killed by a spray of some description, but this is an erroneous idea. White grubs in the soil feeding on the roots, boring insects hatching from eggs laid under the skin of plants, leaf-mining insects working between the two surfaces of a leaf, and others, can not readily be killed by any spray mixture. For these and various reasons it is necessary to understand the life history of insects; then the weakest, most vulnerable period in their career must be selected as the proper time to effect their eradication or suppression.

Nearly all insects succumb to poison fumes like carbon bi-sulphide and hydrocyanic acid gas, and insects in stored grains are best controlled by the fumigation method. With certain garden insects, cultural methods may be the only successful means of fighting them, and at times two or three methods may be combined against a single species.

INSECTS AFFECTING ASPARAGUS

Fortunately there are not many insects injurious to this valuable plant. There are, however, two asparagus beetles, both imported species, that may do considerable damage. Their injury is due to both adults and larvæ feeding on the young, tender, marketable shoots, rendering them unfit for sale, and also to defoliation of older plants. Since their habits and method of injury to asparagus are much the same they will be mentioned here together.

Common Asparagus Beetle *(Crioceris asparagi,* Linn.).
The 12-spotted Asparagus Beetle *(Crioceris 12-punctata,* Linn.).

DESCRIPTION AND LIFE HISTORY.

Beetles.—Are about one-fourth inch in length, both species being somewhat strikingly colored and marked. The common asparagus beetle, shown in Fig. 2, has the thorax or fore part of the body, reddish-yellow marked with two black spots. The wing covers are marked by a bluish-black stripe along the middle line where they meet, and lateral extensions of this main stripe extend toward the edges, which are orange colored. The intervening color is lemon-yellow. The underside of the body and the legs are usually shining black. The 12-spotted beetle is uniformly reddish in color, with twelve black spots on the wing covers (Fig 3). The body is broader than the common species. These beetles cause much damage by gnawing into the young marketable shoots, and later the beetles of the common species help to defoliate the plants, while the 12-spotted beetles feed mainly on the berries.

FIG. 2.—Common Asparagus Beetle on asparagus: Showing eggs, larvæ and adult; asparagus top at right, showing eggs and injury. (Chittenden, Yearbook, 1896, U. S. Dept. of Agr.)

are assisted by the adult beetles. The larvæ, called *"grubs,"* may attain a size of one-fourth inch or slightly longer. They are soft bodied, yellowish or dark gray in color. The larval period varies, but is usually about twelve days, after which they drop to the ground, burrow down and change to pupæ in dirt-covered cocoons.

Hibernation.—The beetles pass the winter hidden about in any convenient shelter, under loose bark of trees, in fence corners, and like places, coming forth in early spring as the asparagus commences growth.

Eggs and Egg-Laying.—The eggs of both beetles are similar in shape, but those of the common species are placed on end, usually in rows, while the others are laid singly and flat against the plant. While the beetles may appear at about the same time, the 12-spotted beetles do not often commence to deposit eggs until a month has elapsed, while the common species commence quite early.

Larvæ and Feeding Habits.—The larvæ of the common asparagus beetle when first hatched do much damage by gnawing into the tender shoots, and in this work they

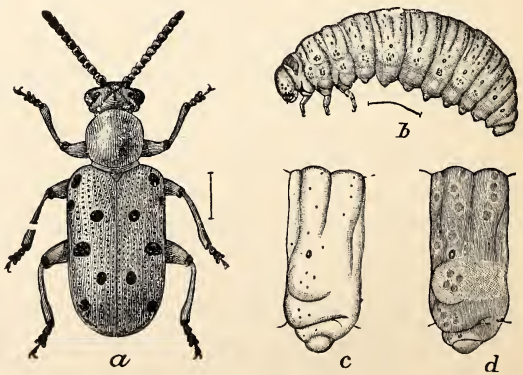

FIG. 3.—12-Spotted Asparagus Beetle: *a*, beetle; *b*, larva. (Chittenden, Yearbook, 1896, U. S. Dept. of Agr.)

As already stated, the eggs of the 12-spotted beetle are deposited late and the larvæ feed on the berries, if present, causing them to drop before ripening. In appearance these larvæ do not differ materially from the ones just described, except for being reddish in color.

Generations.—The life cycle from egg to adult requires only about thirty days, hence there may be several broods each season. The beetles hibernate quite early in the fall.

REMEDIES AND PREVENTION.

Asparagus beetles should be controlled by preventive measures largely, although direct remedies are at times necessary. Commencing early in spring when the beetles first appear, the asparagus grower should aim to destroy all eggs deposited, before they hatch, and supplement this by poisoning the beetles on trap plants. The eggs of the common asparagus beetle are frequently laid in the bud of young shoots just as they appear, or on the stems of any plants in the field. Obviously all old plants, with the exception of a few left as trap plants, should be cut down, and new shoots cut out clean at least every three days. Beetles and larvæ on trap plants may be shaken into a pan of kerosene, and the plants may be dusted frequently with a mixture of lime dust and Paris green, using one pound of the poison in thirty pounds of air slaked lime. The lime dust alone is an effective remedy for the soft bodied larvæ, killing all that it touches, and the mixture acts as a poison to both larvæ and beetles.

Trap plants bearing eggs and larvæ should be cut out frequently—at least once a week, and new plants allowed to grow up in their place. Since the larvæ of the 12-spotted beetle feed mainly in the berries they can not well be poisoned; hence frequent destruction of plants bearing the eggs is advisable. Larvæ of the common species may be shaken from the plants on sunny days when the earth is hot, and many will die before getting back to the plants.

Arsenate of lead (See p. 61), as a liquid poison spray, may be used on fields that are allowed to grow during summer and fall.

INSECTS AFFECTING BEANS.

Bean plants are subject to injury from leaf eating insects from the time they appear above ground; the fruit may be damaged by boring caterpillars; the stored beans partially destroyed by weevils; the seed when planted is sometimes injured by ants and wireworms, and young plants severed by cut worms.

Wireworms (See under Insects Affecting Corn, p. 31).

Cutworms *(Larvæ of Night Flying Moths).*

To gardeners these pestiferous creatures are very familiar. Some, however, may not be acquainted with their life history, or the best

remedial measures. The former is very interesting and indicates how the larvæ should be fought. When beans, and many other garden plants commence to appear in spring, they are cut off at night just above the surface of the soil by these pests. During the day the cutworms lie in shallow burrows in the soil or under any available cover, coming forth to feed only at night. There are a number of species, variously known as greasy, variegated, dark-sided, glassy, clandestine, etc., all having about the same habits, but differing in appearance.

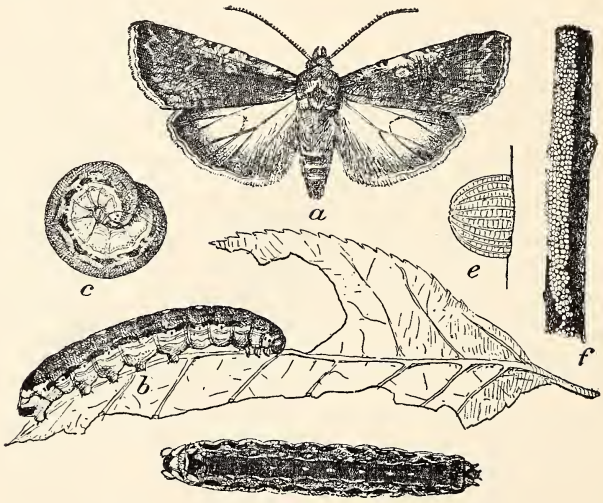

FIG. 4.—Variegated Cutworm, *Peridromia saucia: a*, adult moth; *b*, *c*, and *d*, larvæ (3 views); *e*, single egg much enlarged; *f*, egg mass on grass stalk. (Howard, Div. of Ento., U. S. Dept. of Agr.)

DESCRIPTION AND LIFE HISTORY.

Life History.—Noticeable damage by cutworms occurs mainly in spring when gardens are first started. The worms responsible for the damage are ones that pass the winter in hibernation, awaiting the advent of spring to issue forth in search of food. To appreciate the appetite displayed by cutworms one must understand their life history, which is as follows:

About June or July cutworms become fully grown. They then burrow into the earth, form silk-lined oval cocoons and transform therein to pupæ. About three weeks later the adult parent moths emerge and soon deposit eggs for the next brood. The eggs (Fig. 4, f) are placed on any succulent vegetation, grass or weeds, on which the larvæ, when hatched, feed and become about one-half grown before winter weather drives them into hibernation. The following

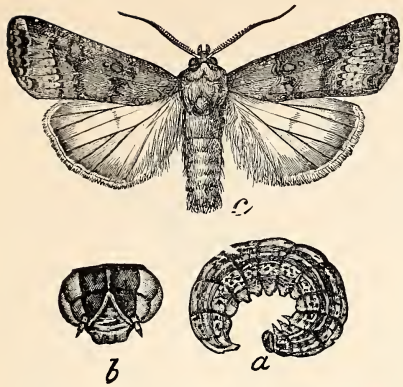

FIG. 5,—Black Cutworm, *Agrotis ypsilon:* Showing larva and adult moth. (Riley and Howard, Div. of Ent., U. S. Dept. of Agr.)

spring they awake with ravenous appetites after their long winter's fast, and naturally devour any green vegetation at hand.

Parent Moths.—The moths shown in Figs. 4 and 5 are of medium size and have wings, which expand one and one-half to two inches. The front wings are dark brown or gray, never conspicuous, but usually bearing a kidney-shaped spot of lighter color; hind wings always lighter than the fore wings. These moths hide during the day, but if disturbed fly with a quick, darting motion.

Larvæ.—All have naked bodies, varying in color from dirty green to gray and brown, but often distinctly marked with longitudinal dark stripes and dots. They have three pairs of true legs at the anterior (head) end and five pairs of fleshy pro-legs behind (Fig. 4, b). When disturbed they always curl up, as shown at Fig. 4, c.

Generations.—Only one generation occurs each year, and the greater portion of their life is passed in the larval stage.

REMEDIES AND PREVENTION.

Preventive measures are preferable to direct remedies, though the latter are fairly successful. Gardens that are in constant cultivation and that are kept free from weeds would not be greatly infested with cutworms, were it not for the ones that wander in from adjoining grass lands, but as this always occurs gardens are seldom exempt from them. The natural food of cutworms is grass, and for this reason sod land during the first year's cultivation is liable to be badly infested.

Cultural Methods.—Gardeners may determine with reasonable certainty what fields are most liable to be infected. Sod land, or grassy and weedy gardens may always be suspected. Such lands should be plowed deeply in fall or early winter to disturb the cutworms in their earthen hibernating cells. Some will be exposed as prey to fowls and birds and some may die from exposure to the winter weather. It has been stated also that the rains soaking into the loosely plowed land will drive some larvæ from their cells. Cross plowing to further disturb and expose the cutworms is certainly advisable.

Domestic fowls should be encouraged to follow the plows, as they will destroy great numbers of insects.

Paper Bands.—In small gardens, plants like tomatoes, cabbages, egg-plants, etc., may be protected from cutworms by bands of stiff cardboard or tarred paper pressed into the soil surrounding the plants. They need not be over one and one-half inches above the soil, as cutworms seldom climb. Occasionally a species of climbing cutworm appears, which must be fought by poison sprays or poisoned bait. Vertical holes with smooth, hard sides made close by the plants, are said to be good traps, as the cutworms crawl into them, and are unable to get out.

Poisoned Bait.—This is no doubt the best remedy to be used against cutworms before the crops are planted, acting as a preventive measure, though it may be used later. To make the best use of poison bait, prepare the garden or field by raking off all vegetation a few days before the crop is planted or seeds come up. Leave the land a few days, which will result in making the cutworms hungry. Then apply a bait made as follows: With forty pounds of corn-meal mix one pound of Paris green or white arsenic; moisten with water to make a rather stiff mash, and sweeten with two quarts of common molasses. Apply this bait about sundown in little heaps at frequent intervals over the field. Repeat this application for two or three nights in succession. In this way, many cutworms will be poisoned, especially if the land is free from vegetation. The bait may be placed in heaps close by plants that should be protected, but the paper bands are more effective.

Another good poison bait is made by cutting some succulent clover and dipping it in a barrel of water containing one pound of Paris green. This may be used while fresh the same way as the corn-meal bait.

All poisoned baits must be used with caution, or not at all, if chickens are liable to get to it.

Bean Leaf Beetle *(Cerotoma trifurcata,* Forst).

Injury is caused by the adults eating round holes in the leaves of beans and cowpeas, while the larvæ feed on the roots or main stem just below the surface of the soil.

DESCRIPTION AND HABITS.

The beetles are about one-sixth inch in length, varying in color from yellowish to reddish with black marking as shown in Fig. 6. When abundant, the beetles may defoliate plants severely. They hibernate during winter and usually appear quite early in spring.

The larvæ are slender in form and whitish in color, and feed on the roots or stems in the manner stated above.

There may be two or three generations. According to Chittenden[1] the life cycle requires from six to nine weeks.

[1] Yearbook Dept. of Agr. 1898, p. 254.

REMEDIES.

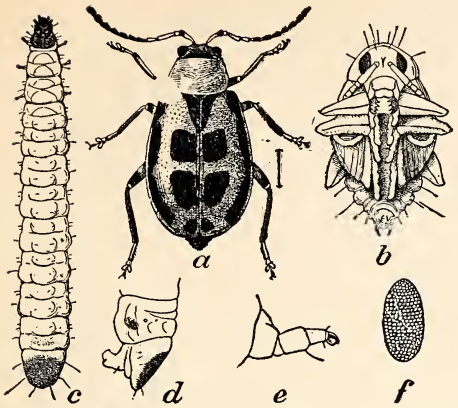

FIG. 6.—Bean Leaf-Beetle: *a*, adult beetle; *b*, pupa; *c*, larva; *f*, egg—*a*, *b*, *c* enlarged about six times, *f*, more enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

Spraying the plants with an arsenical poison, Paris green or arsenate of lead preferably mixed with Bordeaux mixture (See p. 61), is undoubtedly the best remedy. When the early appearing beetles are poisoned later spraying should not be necessary. String beans should not be poisoned when the pods are maturing. Further preventive measures against similar leaf-eating beetles are discussed on page 43 under cucumber beetles.

COMMON BEAN WEEVIL (*Bruchus obtectus,* Say).

The common bean weevil, *Bruchus obtectus,* Fig. 7, as well as other species of *Bruchus,* annually infest quantities of dried beans,

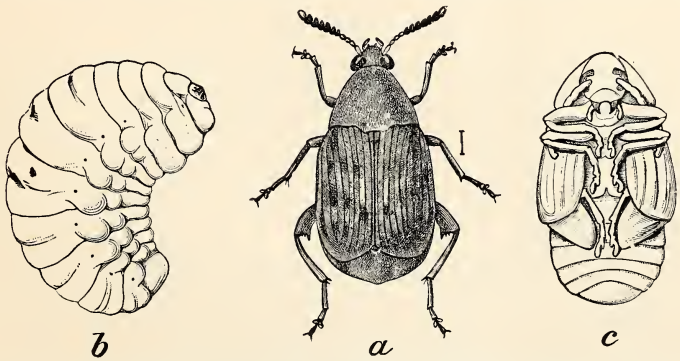

FIG. 7.—Common Bean Weevil, *Bruchus obtectus: a*, beetle; *b*, larva; *c*, pupa—all greatly enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

rendering them unfit for food or seed. Infested beans are readily detected, upon examination, as every housekeeper could testify. Many people believe that beans become infested *only* after they are stored, and such may at times be true, but a large proportion are first infested in the field or garden.

LIFE HISTORY AND HABITS.

Dried stored beans once infested with weevils may continue to become worse infested by successive generations. If not disturbed the

weevils may produce five or six generations each year and single beans may contain a number of weevil larvæ at one time.

Ordinarily, beans first become infested in the field, the weevils depositing eggs through slits or cracks in the green pods, and the larvæ, as soon as formed, bore into the beans. Their presence is indicated only by a small black speck on the skin. In dried beans, the weevils are readily detected because they eat away all but a very thin layer of outer skin.

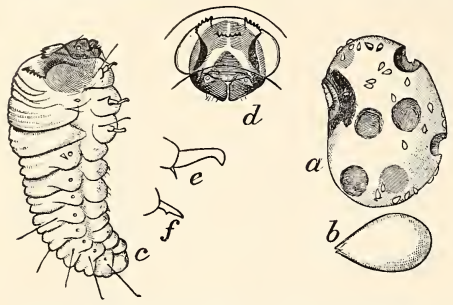

FIG. 8.—The 4-Spotted Bean Weevil, *Bruchus 4-maculata:* Showing cowpea (*a*) with holes made by weevils, and also eggs on the surface; *c*, embryonic larva. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

The adult bean weevil *B. obtectus,* is about one-sixth inch in length, grayish brown in color, and has the end of the abdomen extending beyond the wing covers. Other species of bean weevils differ in size and coloration, but all may be distinguished by the short wing covers. Fig. 8 represents the four spotted bean weevil, *B. 4-maculata.*

REMEDIES.

There is no way of preventing infestation of beans in the field if the parent beetles are present. To prevent their being present stored beans, peas and cowpeas should be thoroughly fumigated during fall and winter, so that no adult beetles may escape. The method of fumigation is fully described under pea weevils, p. 48. (See also corn weevils, p. 39.)

INSECTS AFFECTING BEETS.

CUTWORMS (See under Bean Insects, p. 11).
FLEA BEETLES (See under Cucumber Insects, p. 44).
WEB WORM (See under Cabbage Webworm, p. 23).
WIREWORMS (See under Corn Insects, p. 31).

BEET LEAF-MINER *(Pegomyia vicina,* Lint.).

This insect may not occur in North Carolina, but if not this particular species, some similar ones do occur. The beet leaf-miner is common in States where the sugar beet is grown and may cause considerable injury. Many garden plants are injured more or less by leaf-mining insects, hence the brief account here given of the beet leaf-miner should be of general interest.

Beets and other plants are often found with raised or blistered

blotches, or channels in the leaves, these areas eventually turning brown and dying, rendering them unfit for greens. The cause of this damage is a small larva or maggot feeding between the two surfaces of the leaf.

The adult of the species mentioned above is a two-winged fly, resembling the common house fly, only smaller. The eggs deposited by these flies hatch into minute maggots, that bore at once into the leaves. When grown the maggots usually leave their channels to pupate.

PREVENTIVE MEASURES.

As sprays are useless to poison the larvæ, the gardener's recourse is to destroy the infested leaves. When beets, turnips, etc., are used for greens, all discarded leaves should be burned rather than left in the fields. The insects pass the winter in the pupæ stage under leaves and rubbish, and may be destroyed by clean cultural methods.

INSECTS AFFECTING CABBAGE, COLLARD AND CAULIFLOWER.

A long list of insects are known to attack these and closely related crops, and since no garden operation is complete without these valuable plants, their insect enemies should be well understood.

Cutworms.—(See under Bean Insects, p. 11).

Flea-Beetles.—Poison applications used against cabbage worms, p. 22, should also control the flea-beetles. The reader should refer also to control of flea-beetles on cucumbers, etc., p. 44.

Cabbage Aphis (*Aphis brassicæ*, Linn.).

Green lice on cabbage, collards, and related crops, familiar to all gardeners, may appear early in the spring, but are generally most abundant and destructive in late summer and fall. Particularly is this true in fall after cool weather commences, and is due mainly to the fact that natural parasitic enemies are able to keep the lice reduced to small numbers during warm weather.

LIFE HISTORY AND FEEDING HABITS.

Cabbage aphis, like all plant lice, feed by piercing the plant tissue with their long, slender beaks and sucking the plant juices. When numerous they may cause plants to wither and die, and only small numbers may serve to stunt the growth. These lice multiply very rapidly, the young being born alive by both winged and wingless viviparous females. The winged females serve to spread the colonies, that is, a single winged individual may fly to an uninfested plant and start a new colony. No true males and females are present during

the summer months, but are developed by the last brood. A winged male is shown in Fig. 9, a. The true females develop eggs that serve to carry the species through the winter. Colonies of cabbage lice are usually more or less covered with a white powder, which they secrete, and great numbers of molted skins are always present.

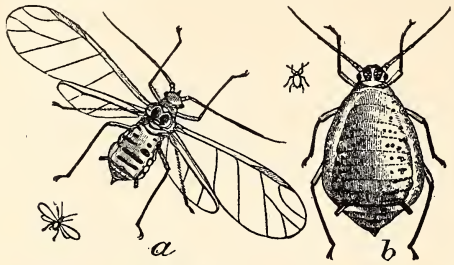

FIG. 9.—Cabbage Louse: *a*, winged male; *b*, wingless female—much enlarged.

PARASITES.

Were it not for the number and activity of parasites attacking the cabbage aphis, this would be a very serious pest. Predaceous parasites, such as lady-bird beetles and their larvæ, and aphis lions, together with internal parasites belonging to the Hymenopterous insects, usually serve to keep the aphis down to comparatively small numbers during warm, dry weather in summer. Later, the lice become more numerous, mainly because their parasites are not so active or else they stop work entirely because of the cold weather.

REMEDIES.

Soap Solution.—For all lice, as previously stated, contact sprays of sufficient strength are effective. It is surprising how easy the cabbage lice may be killed with soap solution, which acts by suffocation and caustic effect. Ordinary strong potash washing soap, or powder, will do the work. Dissolve one pound in about four gallons of water and apply to infested plants with considerable force and in liberal quantities. The lice are often so thickly massed together that those underneath will escape unless the solution is applied as a fine spray and with *force.* A spray pump is quite necessary and should be provided with a short hose and extension rod with a curved end, in order to throw the spray on the under sides of the leaves. Failing in this, the leaves must be turned over and the colonies of lice saturated with the solution. *Simply sprinkling the tops of infested plants does very little good.*

Other Contact Sprays.—Kerosene emulsion of 10 part concentration, tobacco decoction, pyrethrum powder and whale oil soap (See p. 63 for direction for preparing) are all good remedies, but not superior to common soap solution when properly applied.

TERRAPIN OR HARLEQUIN BUG *(Murgantia histrionica,* Hahn.).

This gayly colored plant bug, so common and destructive, is another sucking insect, feeding on the plant juices. Its attack is more serious than the plant lice because, in addition to sucking the sap, it

injects into the plant tissue a poison that causes the foliage to turn brown, shrivel and die. A very few terrapin bugs may kill young plants. They attack all cruciferous crops.

DESCRIPTION AND HABITS.

Adult Bugs.—The fully grown bugs are about three-eighths inch in length, and one-fourth inch wide. The head is short, with the long beak springing from beneath and lying between the legs when not in use. The body presents a blunt, broad-shouldered appearance. The general color is black with orange or yellow markings. (See Fig. 10.)

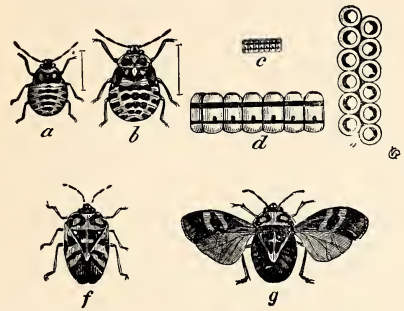

FIG. 10.—Terrapin Bug: *a* and *b*, nymphs; *c*, eggs; *d*, eggs enlarged; *f* and *g*, adult bugs.

The adults live in hibernation during winter in any protected place.

Eggs.—Are usually laid on the under sides of the leaves in double rows of twelve, as shown in Fig. 10, e. Each egg appears barrel-shaped and is marked by black bands, Fig. 10, d.

Nymphs.—The young, called nymphs, resemble the adults except that they are smaller and lack wings. In this stage they have comparatively soft bodies and succumb to strong contact sprays.

REMEDIES AND PREVENTION.

Old fields of collards and similar crops are veritable feeding grounds for terrapin bugs. By thorough cleaning up of such fields in fall much trouble may frequently be averted. Strict cleaning up and burning of all stray plants and rubbish about gardens and fence corners during winter will destroy many hibernating adults.

Trap Plants.—The adult bugs, first appearing in spring, seem to be partial to mustard, radish and rutabaga plants, and these may be planted early and used as trap plants. Only a few are necessary. The bugs that gather on such plants may be collected by hand or shaken into a pan containing a little kerosene, and when eggs are deposited and nymphs appear they may be killed by spraying with 15 per cent kerosene emulsion, or with pure kerosene, but the latter will kill the plants. When the trap plants become too badly infested, they may be pulled and burned. Persistent warfare in early spring should so reduce the number of bugs as to protect the later crops.

Kerosene Emulsion.—When used liberally of 15 per cent concentration (See p. 63) this will kill all the young and nearly mature

nymphs that it comes in contact with and will kill some adult bugs. Before the wings are developed, the bugs are not so difficult to kill. Two or three such sprayings at intervals of five or six days should nearly exterminate the bugs, even on badly infested crops.

When spraying with emulsion, many bugs drop from the plants to the ground, and should be thoroughly saturated where they lie, and this is quite important, as very few will live to return to the plants. Kerosene emulsion must be properly prepared, so that the oil does not readily separate, otherwise the plants may be injured by the spray.

CABBAGE WORMS.

No less than five distinct species of leaf-eating worms are annually present, and are quite injurious to cabbage, collard, turnip and related plants. One species, the cabbage web worm, has never before been reported as occurring in North Carolina. In addition to the five different worms mentioned below, cabbage and related crops may at times be attacked by the larvæ of the Southern cabbage moth, zebra caterpillar, army worm, corn worm, yellow woolly bear, and possibly other minor leaf-eating pests. The following, however, are the only ones that the gardener need fear:

Imported Cabbage Worm *(Pontia rapæ,* Linn.).

As the name implies, this destructive pest was introduced into this country from Europe, first appearing in the United States about 1865. It is now prevalent throughout North America and Europe. Although an introduced pest it has far outstripped in numbers the native cabbage worm, described further on.

DESCRIPTION AND HABITS.

Parent Butterfly.—The parent of the imported cabbage worm is a white-winged, active, day-flying butterfly. The majority of the white butterflies that hover about cabbage and collard fields on bright, sunny days are the adults of this species.

The female butterflies have white wings expanding about one and three-fourths inches, the front wings having a black spot at the tip and two black dots near the center, while the hind wings have only one black dot near the front margin (Fig. 11). The males differ in having only one black dot on the forewings, but otherwise closely resembling the females. The butterflies deposit eggs on all cruciferous crops, but particularly on collard, cabbage, and cauliflower.

Eggs.—These are laid on the under sides of the leaves; they are oval in shape, white at first, but soon assume a yellow color, and hatch

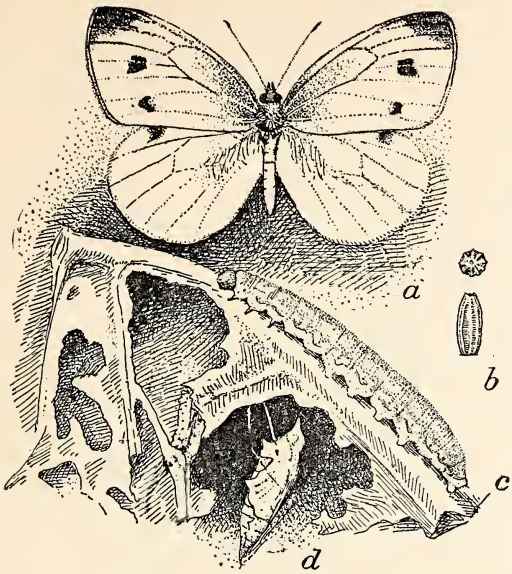

FIG. 11.—Imported Cabbage Worm: *a*, female butterfly; *b*, egg—much enlarged. *c*, larva in natural position; *d*, pupa suspended; (Chittenden, Cir. 60, Bur. of Ent., U. S. Dept. of Agr.)

in four to eight days. They may be easily located on the plants by watching the female butterfly as she deposits them one at a time.

Larvæ.—The larvæ or young worms feed on the lower surface of the leaves, or in the opening bud, and rapidly increase in size, attaining full growth in about two weeks. They then appear green in color, one and one-fourth inches long, with a pale yellow stripe along the middle of the back. The body is clothed in short hairs, giving it a velvety green appearance. They move slowly without lifting the body, which they are enabled to do by possessing eight pairs of legs. This species seems to prefer to feed on the central leaves.

Pupæ.—The grown larvæ change to naked pupæ suspended to the underside of a leaf by a silken cord about the body and the tip of the abdomen attached to a mat of silk. Fig. 11, d, represents a pupa suspended, but not in its natural condition. The pupæ are irregular in shape, light green, and inactive except for being able to wriggle the abdomen when disturbed.

LIFE HISTORY.

Pupæ, also known as chrysalides, of the last fall brood, live through the winter. In the spring they transform into butterflies, which soon commence to deposit eggs. In warm weather the entire life cycle from egg to butterfly is completed in about thirty days, or less, so that five or six broods may develop during the year in the South. There are three broods in the New England States.

This, we see, is an insect having four distinct stages of development as already described, and naturally the larval or feeding stage is the time when it may be destroyed most readily, although adults may be caught in nets, and pupæ sought for and destroyed.

REMEDIES.

Poison Sprays.—A prejudice seems to exist against the use of poison sprays on cabbage, collard, etc., but it is largely without foundation. Garman, Entomologist of Kentucky, has made exhaustive experiments with Paris green mixture and found that it may be used safely if reasonable care be exercised in its application. Certainly the arsenical sprays are more effective against the worms than most other remedies on young and half grown plants. Garman sprayed cabbages four times with Paris green mixture, using as much as one pound of Paris green in one hundred gallons of water, and about two weeks after the last application he had entire cabbage heads, outer leaves and all, subjected to chemical analysis. Only a slight trace of poison could be detected; not enough to poison a person under any conditions. As cabbages grow from the inside outward, and the outer leaves are always removed before cooking, the writer does not hesitate to recommend the use of arsenical sprays until within three or four weeks of the time when such plants will be eaten. Cruciferous plants grown for greens alone may be poisoned also, using the same precaution. Resin-lime mixture, or Paris green-lime mixture, as recommended under formulas, page 62, will suffice to keep this and other cabbage worms in control. Four annual sprayings are usually sufficient.

Fresh hellebore acts as a poison both by contact and internally. It may be dusted on infested plants every two or three days, or used as a liquid spray.

Contact Sprays.—Cabbage worms, being soft-bodied and breathing through pores in the body, will succumb to contact sprays such as ten per cent kerosene emulsion, strong soap solution, or by dusting with common ar-slaked lime or ashes. Hand picking of worms from small areas is often advisable.

Preventive Measures and Trap Crops.—All remnants of cruciferous plants should be removed from the gardens and fed to stock or burned as soon as the crop is gathered, especially during late fall and winter, for the destruction of such plants will destroy many overwintering pupæ of the imported cabbage worm, and also those of nearly all injurious cabbage worms. Trap plants may be left in the field in fall to attract the butterflies to deposit eggs, but these should be freely poisoned and destroyed entirely before spring.

Parasites.—Several parasitic enemies assist in keeping the imported cabbage worm in control.

Native Cabbage Worm *(Pontia protodice,* Bd.).

Unlike the cabbage worm just described this is a native North American species, and is said to be more abundant in the South than

in the North. Near Raleigh during October, 1907, no worms of this species could be found, but earlier in the season they were probably numerous. Doubtless the parasites got very active and nearly exterminated this species in this section last fall.

DESCRIPTION AND LIFE HISTORY.

The adult male butterflies resemble the imported species, already described, in size and color, but differ in having four angular spots on the front wings and small black marks near the tip, while the hind wings are not marked. The females differ very greatly in having both pairs of wings liberally checkered with angular black spots.

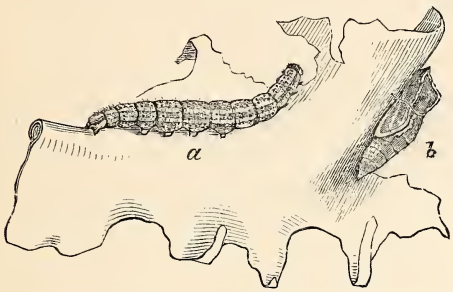

FIG. 12.—Native Cabbage Worm: *a*, larva; *b*, pupa. (Yearbook, 1883, U. S. Dept. of Agr.)

The eggs are laid singly on the undersides of the leaves.

The larvæ (worms) are greenish or purple in color and differ from the preceding form by having four longitudinal pale yellow stripes along the back. The head and body are dotted with black. The pupæ resemble those of the imported species and are similarly attached to the leaves (Fig. 12).

The life history of this species is practically the same as that of the imported cabbage worm.

REMEDIES.

The remedy is the same as for the imported species and one can not well be controlled without destroying the other.

Parasites.—Several beneficial parasites attack the native cabbage worm, often rendering other remedial measures unnecessary.

CABBAGE WEBWORM (*Hellula undalis,* Fab.).

Another imported pest of cruciferous crops is the webworm, a most injurious species, new to North Carolina, and of a comparatively recent occurrence in North America. The writer first discovered this pest quite abundant on turnips at West Raleigh in October, 1907, and it appears never to have been discovered previously in any part of this State. The webworm had of course been here all through 1907 and probably one or two years before, but without being detected.

HISTORY OF THE CABBAGE WEBWORM.

This insect was discovered in injurious numbers near Augusta, Ga.,

in 1898, but had been observed there the previous year. In Richmond County, Ga., in 1898, the damage caused by webworms to turnips, cabbage, beets, etc., was estimated conservatively at $20,000, and by some persons as high as $50,000. This serious outbreak led to an investigation by the Bureau of Entomology, Washington, D. C., which brought out the fact that the same insect had appeared near Charleston, S. C., in 1895, considerable damage in that vicinity being reported also in 1896. Three years later, in 1899, injury from webworms was reported from Auburn, Ala., and Athens, Ga., but the damage near Augusta, Ga., was not nearly so great as it had been in the year 1898.

From the information available it is thought that the cabbage webworm was first introduced near Charleston, S. C., and spread from there to Augusta, Ga. Now that it has been found at West Raleigh there is every reason to believe that in many places in North Carolina it already has a good foothold. Therefore our farmers and gardeners should study the following description and learn to recognize the pest.

INJURY CAUSED BY WEBWORMS.

The worms seem to prefer feeding in the bud of young plants or on the undersides of the leaves, or in the crown of plants like turnips and beets. On turnips, they may burrow into the crown, making shallow channels, and also eat off the leaves at their bases. The worms cover themselves with a web, probably remaining under it most of the time, though they may leave it at night to feed. When grown the worms spin silken cocoons, which are usually imbedded in a mass of web. Young plants are prevented from growing by the worms eating the bud, and older plants may be ruined in a few days if the worms are abundant. The presence of webworms is indicated by webs between the bases of the leaves of cabbage, collard, etc., and in the crown of beets and turnips. The worms may usually be found under the webs.

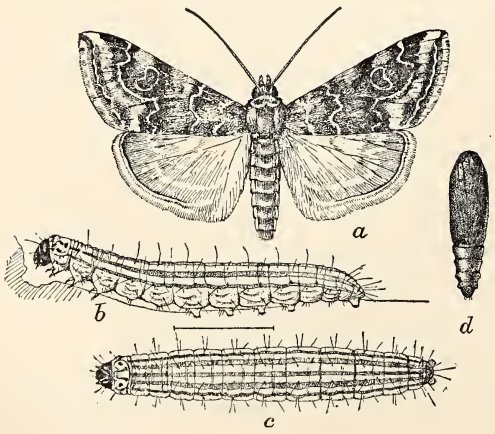

FIG. 13.—Cabbage Webworm: *a*, parent moth; *b*, and *c*, larvæ; *d*, pupa—all 3 times natural size. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

DESCRIPTION AND HABITS.

Eggs.—Eggs are laid singly or in masses, according to Chittenden,[1] and are at first white, changing to pink; the shape is oval, size small, but discernible to the naked eye; they hatch in three to four days.

Larvæ.—Full grown webworms are quite distinctive in appearance. They measure a little over one-half inch; color yellowish gray, marked above by five noticeable brownish stripes (Fig. 13, b, c); body dotted by a few yellowish or brownish hairs. The larvæ have eight pair of legs, three pair true legs in front and five pair pro-legs behind.

Pupæ.—These are not readily found because of being enclosed in tough silken cocoons spun between the leaves or in the crown of turnips and beets. The pupæ are shiny yellowish brown in color, and are about three-tenths of an inch in length (Fig. 13, d). As they pass the winter in this stage an excellent opportunity is presented to reduce their numbers by clean cultural methods.

Parent Moths.—In general shape and markings the moth is well shown in Fig. 13, a, much enlarged. The true size is about three-fourths inch when wings are expanded, but when resting with wings folded over the body they appear much smaller. The fore-wings are gray, marked with both darker and lighter stripes and spots. Hind wings are lighter in color. The moths fly and deposit eggs at night, and hide during the day.

Generations.—No definite information concerning the number of annual broods for North Carolina is available. We do not know how early the webworms become abundant, nor much about their life history. On this point, and many others, the writer hopes to get definite information this coming summer by field and laboratory observations. The life cycle as determined by Chittenden is about 27 days, but will, no doubt, be found to vary.

REMEDIES.

Arsenical Poisons.—Poisons if effective must be applied early, for when the protecting webs have been spun, poison sprays will not be of value. If the worms are detected when they first appear, some of them, and especially succeeding broods of larvæ may be poisoned. In other words, a poison spray applied thoroughly so as to penetrate well in between the bases of the leaves where the webworms commence to feed will kill many of the young. For this spray, it would be best to use Paris green, at a strength of 1 pound to 125 gallons of water with lime (See p. 60) or arsenate of lead at the usual strength. Dry dust poison applications may answer the same purpose if applied

[1] Burean of Ent. Bul., 23, p. 59.

with a good powder dust gun that will throw the mixture forcibly into all crevices. As soon as the first worms appear apply poison liberally.

Trap Crops.—Webworms seem to prefer cabbage and turnips, hence it would seem that these might be planted early and thoroughly poisoned to destroy the early broods. This would be a great protection to later crops of similar and related plants.

Clean Culture.—Webworms may undoubtedly be prevented from increasing in numbers by carefully burning or feeding, if suitable, all remnants of infested plants during fall and winter. When early crops are infested burn or feed the plants when the crop is gathered. Such practice is advisable against other cabbage worms that pupate on the plants and winter in that condition.

Cabbage Looper (*Autographa brassicæ,* Riley).

This is probably the most injurious cabbage worm in North Carolina. Cabbages, collards, and rutabaga turnips are often almost stripped of their outer leaves, and the worms may bore into the cabbage heads. They move by a looping motion, rendering them easily recognized from the other common cabbage worms.

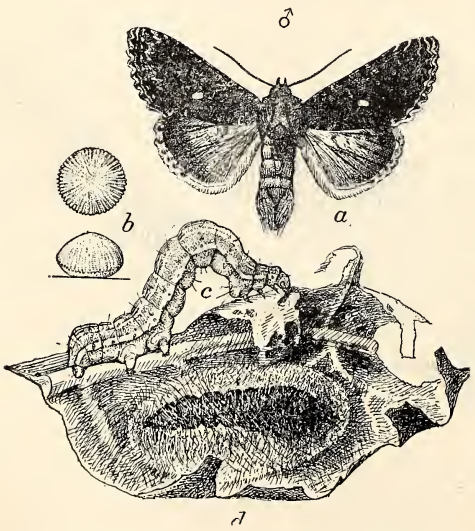

Fig. 14.—Cabbage Looper (*A. brassicæ*): *a*, male moth; *b*, egg (two views); *c*, larva in natural position; *d*, pupa under thin cocoon—*a*, *c*, *d*, slightly enlarged; *b*, more enlarged. (Chittenden, Bul. 33, Bur. of Ent., U. S. Dept. of Agr.)

Description and Habits.

Eggs.—Are small, pale green, round and flattened on one side with convex side up, and are deposited singly or in small clusters by the female moths about sundown or at night.

Larvæ.—When full grown they are one and one-half inches, or more, in length, pale green, marked with four fairly distinct stripes along the back. Less distinct longitudinal lines also occur. The body is smallest at the anterior end and bears three pairs of true legs on the first three segments, and three pair of pro-legs near the caudal end, one pair being on the last body segment (Fig 14, c.).

Because of not having pro-legs in the middle of the body these caterpillars move with a semi-looping motion, much like the familiar "inch or measuring worm."

Pupæ and Cocoons. The larvæ change to pupæ under thin silken webs on the under sides of the leaves, as shown in Fig. 14, d. The pupæ are about one-half inch long, shiny brownish in color, and may be seen through the thin webs.

Parent Moths.—From the pupæ, moths as shown at Fig. 14, a emerge to lay eggs for the succeeding brood. The moths have a wing-expanse of nearly one and one-half inches; fore-wings grayish brown and marked by a silvery dot and loop near the center; hind wings are lighter. They fly at night or about sundown, and hence escape observation.

Generations and Winter Stage.—Several generations occur each year and are checked only by cold weather. The last brood passes the winter as pupæ, which shows that fall and winter destruction of old infested plants should be practiced.

REMEDIES.

All remedial measures, trap plants, clean culture, etc., suggested above to be used against the imported cabbage worm, should be employed against this species.

Diamond Back Moth or Cabbage Plutella (*Plutella maculipennis,* Curtis).

Although a small worm, this species may cause considerable damage by feeding on the undersides of the leaves and producing small, round holes. They do not often cut through to the upper surface. The larvæ much resemble the young imported cabbage worms, but may be distinguished from them by being extremely active if disturbed.

The parent moths are only about one-fourth inch in length and are seldom seen. They lay minute whitish eggs, which hatch within a few days. The larvæ are a little over one-fourth inch in length, of a pale green color, and when grown encase themselves in white cocoons, which are attached to the leaves. There may be several broods during each season.

REMEDIES.

Poison Spray, as previously recommended, is effective, and Garman states that tar-water has been found very effective in European countries. The winter is passed in the pupa stage, hence clean culture is most advisable.

Cabbage Root Maggot *(Pegomyia brassicæ,* Bouché).

Small, white footless maggots sometimes infest the roots and base of cabbages and radishes and other related crops. There are probably two or three species of cabbage maggots in North Carolina, but a description of the one mentioned above will serve to give the gardener or trucker an idea of these pests and their habits.

DESCRIPTION AND LIFE HISTORY.[1]

Maggots are the young or larvæ of two-winged flies (Fig. 15). This species somewhat resembles the common house fly, only they are much smaller. They pass the winter as adults or pupæ, the latter remaining close to the roots of the plants on which the maggots subsisted. The flies appear in spring at about the time young cabbage plants are set out, and lay eggs on their stems or on the soil close by. The maggots feed on the outer roots, or stems when the latter is not too tough and hard.

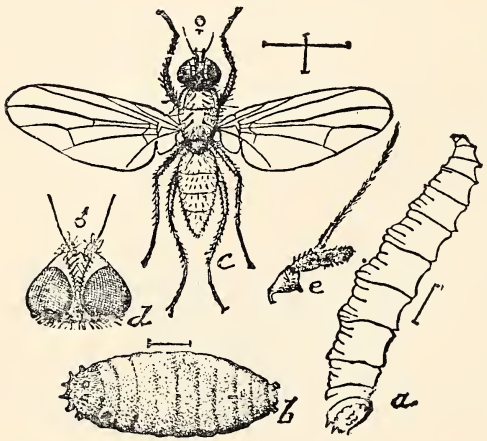

Fig. 15.—Cabbage Maggot: *a*, larva; *b*, pupa; *c*, adult. (Riley).

The presence of maggots is indicated by wilting and drooping leaves, and a general weakened appearance of the plants. It is said that plants infested when young will surely die, unless some good remedial measure is applied.

REMEDIES AND PREVENTION.

Tobacco dust applied liberally about the plants when first set out is of some benefit as a repellent.

Carbolic acid emulsion as recommended against the onion maggot, p. 47, may be used as a repellent.

Quick Acting Fertilizer.—Concerning the use of fertilizers Dr. Smith says: "A combination recommended consists of:

Nitrate of Soda	700 lbs.
Acid Phosphate	1,000 lbs.
Muriate of Potash	300 lbs.

[1] N. J. Sta. Bul., 200.

"The practice of plowing away from onion rows when infestation was noted and applying the above combination, or even nitrate of soda alone, has been followed with good results in Cumberland County, but has failed on heavier soils where the fertilizer did not get so quickly through the soil, and into direct contact with the plants and maggots. Both the nitrate of soda and the muriate have insecticidal qualities, but the acid phosphate has none. Manure and organic fertilizers should be avoided, if possible, as the group of insects to which these root maggots belong are naturally feeders in decaying matter, and hence such conditions tend to invite them."

Prevention.—Pull up and burn or otherwise completely destroy all stumps of plants, of whatever crop may have been attacked by maggots. Practice rotation of crops, for the parent insects do not fly very far. The cabbage maggot will breed in wild cruciferous plants, including some common weeds, such as mustard, hence all such should be destroyed. A good precaution when setting cabbage, or similar plants, is to press the soil firmly about the stem, as it will help to retard the maggots, when hatched, from getting down to the soft roots.

Planting an excess of seed when drilled in rows may insure getting a stand even where a large number of plants are attacked by maggots. The plants that become infested should be pulled out and destroyed. The reader should refer also to p. 47 concerning treatment for the onion maggot.

Cabbage Snake (*Mermis albicans,* Diesing).

During recent years much excitement has been caused by the discovery of slender, white worms in cabbage heads, known as "cabbage snakes," and which have been reported as being deadly poison. How such accounts have originated it is hard to realize. The "cabbage snake," so called, commonly found, is shown in Fig. 16. It is an "eel-worm" or "hair worm," and occurs as an internal parasite in the bodies of grasshoppers, happening at times to escape from its host onto cabbage heads, which alone accounts for its presence there. These slender, thread-like creatures are active and repulsive looking, but never poisonous.

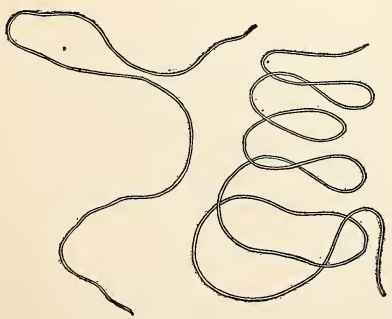

Fig. 16.—"Cabbage Snake" or Hair-Worm: Natural size. (Chittenden, Cir 62, Bur. of Ent. U. S. Dept. of Agr.)

Small, segmented, reddish earthworms occasionally get into cab-

bage heads, by being accidentally lodged there with small clods of earth during cultivation. There is no danger from eating cabbage that have contained these worms, or the common "cabbage snake."

INSECTS AFFECTING THE CELERY PLANT.

Cutworms.—(See under Bean Insects, p. 11).

Celery Caterpillar *(Papilio polyxenes*, Fab.).

This is a very large, conspicuous green and black caterpillar, familiar to many children because of its peculiar appearance. It seldom appears in great numbers, but if present is a voraceous feeder on various plants, including celery, carrot, parsley, caraway, parsnips, and related wild plants.

DESCRIPTION AND HABITS.

Caterpillars.—Are about two inches in length, green in color, with rings of black, which in turn bear yellow spots. The head bears a pair of horn-like processes that may be thrust out and which emit a disagreeable odor. The body is thrown into a peculiar defensive like attitude when disturbed.

Pupæ.—When full grown the caterpillars generally desert the plants on which they fed and crawl to some convenient place to pupate. The pupæ are naked, of an ash-gray color, and are suspended by a silken band and mat of silk at the caudal end. In this quiescent stage they pass the winter.

Parent Butterfly.—The adult form, commonly known as the "black swallow-tail," is very conspicuous. The wings are blackish-brown, and marked with yellow and orange bands and spots.

REMEDIES.

As there may be several broods each season the gardener should be on the watch for their first appearance. The caterpillars are so conspicuous that hand picking is probably the best remedy, and if the larvæ of the first brood are destroyed later injury may be prevented. Paris green mixture (See p. 60) will be found effective and might be used with profit on the young plants in extensive celery fields.

Other Caterpillars Attacking Celery.

Celery Looper, *Plusia simplex,* closely related to the cabbage looper, and the celery leaf-tyer, *Phlyctænia ferrugalis,* is a small caterpillar that usually feeds on the terminal leaves and may at times become troublesome. Spraying young plants with arsenical poisons should prove effective, and is perfectly safe if the poison is used in reasonable amounts.

Celery Lice.

Celery is occasionally infested with plant lice of various species, whose attack results in lessened vitality and dwarfed plants. Should this occur, a thorough spraying with soap solution, as suggested for cabbage aphis, p. 18, will be found effective. Soap solution may be applied frequently without injury. Tobacco decoction is always quite effective against plant lice.

Red Spider *(Tetranychus spp.)*.

These little creatures, frequently called mites, are not true insects. They are, however, a very common garden pest, and attack at times almost any vegetables, particularly cucumbers, cantaloupes, egg plants and many common crops. They are most abundant during hot, dry weather, and then if present they cause the foliage to turn yellow and eventually die. The individuals are very small and rather active; and may feed on both upper and lower surfaces of a leaf, spinning over it a thin web for protection.

REMEDIES.

Abundant moisture will keep red spiders in check. When a good spray or force pump is available, they may be controlled by simply making frequent applications of ordinary clear water, applied with all the force the plants will endure, washing both sides of the leaves. This method is used in greenhouses, to keep the mites off of violets, roses and other plants.

Powdered sulphur (flowers or flour of sulphur) applied as a fine spray, using one ounce of sulphur in a gallon of water or the dry powder dusted on the plants when wet with dew will be found very effective. Potassium sulphid *(liver of sulphur)* obtainable from drug stores, may be used as a spray of one ounce in three gallons of water. It is said that a little whale oil soap, tobacco-stems water, or milk of lime added to the sulphur mixture increases its efficiency.

INSECTS AFFECTING SWEET CORN.

Numerous insects attack corn, some injuring the seed when first planted, some damaging the young plants, others attacking the stalk and ears when partly grown, while still others damage the stored grain. Only the most common injurious forms will be mentioned here, as the entire space of a bulletin is needed to adequately discuss all the corn insects.

Wireworms *(Several Species)*.

These insects hardly require description, as they have become so well known by their attacks on various crops. Wireworms injure

corn by the larvæ boring into the kernels when first planted and later by entering into the stalk of young plants, causing them to die in the same way as when injured by budworms or rootworms.

DESCRIPTION AND HABITS.

Larvæ.—Wireworms in general may be described as having long, slender, cylindrical, firm bodies, showing segmentation, usually flattened toward each end. They vary in size according to the species to which they belong, some being less than one, others nearly two inches long. The majority are reddish or yellowish in color, presenting a very hard, slick appearance. Some wireworms feed on decaying wood and organic matter, while others subsist on seeds and roots of plants.

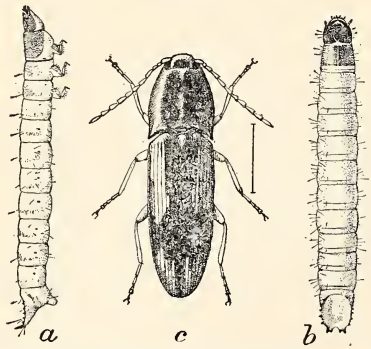

FIG. 17.—Wireworms: Larvæ and adult—all three times natural size. (Chittenden, Bul. 33, Bur. of Ent., U. S. Dept. of Agr.)

Parent Beetles.—These are commonly known as Jack snappers, click beetles, thumping beetles, and by other terms, gained for them by the power of springing several inches in the air, in an effort to turn over when laid on their back.

The common click beetles are from one-third to one inch in length, generally of a brown color and are variously marked. A common species is pictured in Fig. 17.

LIFE HISTORY.

The parent beetles may hibernate in protected places, but many larvæ pass the winter in the soil. It is thought that most species of wireworms require three years to mature, hence two winters of their life must be passed in the ground. This fact shows how difficult it may be to free a field from these pests. The beetles of the injurious species, generally deposit their eggs in grassy places, though the species that feed in decaying wood may lay eggs in old stumps, etc.

REMEDIAL MEASURES.

No single method of control is effective. Various methods of reducing the numbers of wireworms in fields already badly infested have been advocated. The most promising are, early fall plowing to disturb the larvæ, followed by cross plowing and harrowing once or twice during winter, and the use of poison baits in spring. A good bait is made by treating slices of potatoes or turnips with strichnine, and other baits are mentioned under remedies for cutworms, p. 14.

Crops peculiarly liable to attack, like corn, potatoes, beets, turnips, etc., should never be planted on land known to be infested, unless absolutely necessary.

Rotation of crops may do some good. It is difficult to name an immune crop. Legumes, as a rule, are not much injured by wireworms, but that may be due to their abundant root system. A rotation that allows the land to be broken every fall or winter will naturally tend to reduce the numbers of these insects.

Planting an excess of seed when corn must be planted on infested land may insure getting a stand.

Corn Rootworm (Budworm), *(Diabrotica 12-punctata,* Oliv.).

This corn pest belongs in the same category as the wireworms in being difficult to control. Rootworms damage young corn plants by

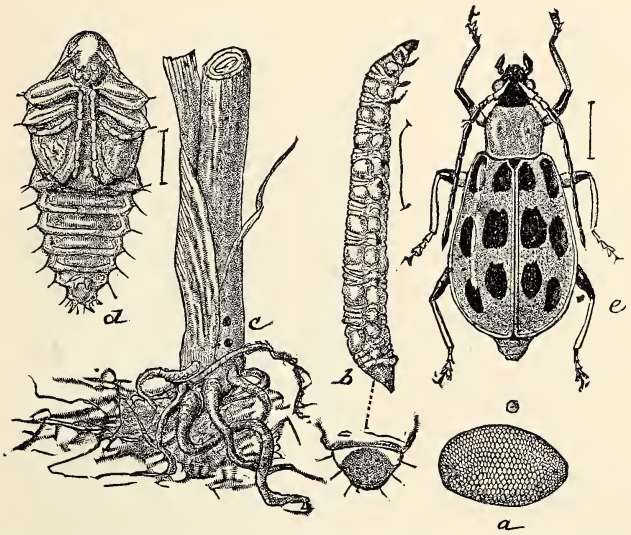

Fig. 18.—Corn "Root-worm" or "Bud-worm": *a*, egg; *b*, larvæ; *c*, injury o corn plant; *d*, pupa; *e*, adult beetle—all except *c* much enlarged. (Redrawn from Riley, Div. of Ent., U. S. Dept. of Agr.)

eating into the stalk at or near the ground, and very young plants may be killed outright, while older ones will be caused to make a dwarfed growth because of having the central bud destroyed. Fig. 18 illustrates the insect in its different stages, and an injured plant.

DESCRIPTION.

Larvæ.—These are slender, yellowish white grubs with a brown head and body about one-half inch long. They attain full growth in three to four weeks.

Pupæ.—The larvæ change to naked whitish pupæ in little cells in the soil, and after about two weeks transform again to beetles.

Parent Beetles.—Are about three-tenths of an inch long, yellowish green in color, with twelve black spots on the wings as illustrated in Fig. 18, much enlarged. These beetles are omniverous feeders on a great variety of plants, notably cucumbers, cantaloupes, etc.

LIFE HISTORY.

After passing the winter in hibernation the beetles become active early in the spring. The earliest vegetables of the garden serve as their food, working, as they do, side by side with cucumber and flea beetles. The eggs, deposited in the soil close by the base of corn plants, hatch within a short time and the newborn larvæ burrow into the stem as indicated above.

There are at least two generations, the first maturing within about six to seven weeks after the eggs are deposited. The parent beetles are present all summer, often feeding on the blossoms of fruit trees.

REMEDIES.

Commencing in early spring and following this insect through its two generations, we discover no good chance of destroying the larvæ, but there is some opportunity of killing the pupæ in the soil and of poisoning the adult beetles. The latter method, however, offers only a slight chance, for the beetles do not all feed in the gardens. Still the liberal use of poisons on cucumbers and cantaloupes, as recommended on page 43, will undoubtedly destroy some of them. Some of the pupæ may be killed by thorough weekly cultivation of the corn crop, especially during and about the sixth to tenth week after it comes up.

Good fertilization to strengthen and feed the corn plants will aid materially against slight attacks, and planting an excess of seed will often insure a stand even though the rootworms may be abundant.

Late Planting and Lowlands.—Delaying the planting of corn until two or three weeks after the usual time will allow many beetles time to deposit eggs elsewhere, thus gaining some protection. The ideal time to plant corn must be determined by experience. Corn rootworms are *liable* to be most abundant in lowlands—but they are not very choice in the selection of a feeding ground—hence some advocate the avoidance of such lands for corn.

As Sherman,[1] in writing of corn insects, has said, "All these measures will help *'some,'* but no one alone will insure immunity from attack of rootworms."

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[1] Bul. N. C. Dept. Agr., Vol. 26. No. 5.

Larger Corn Stalk Borer (*Diatræa saccharalis,* Fab.).

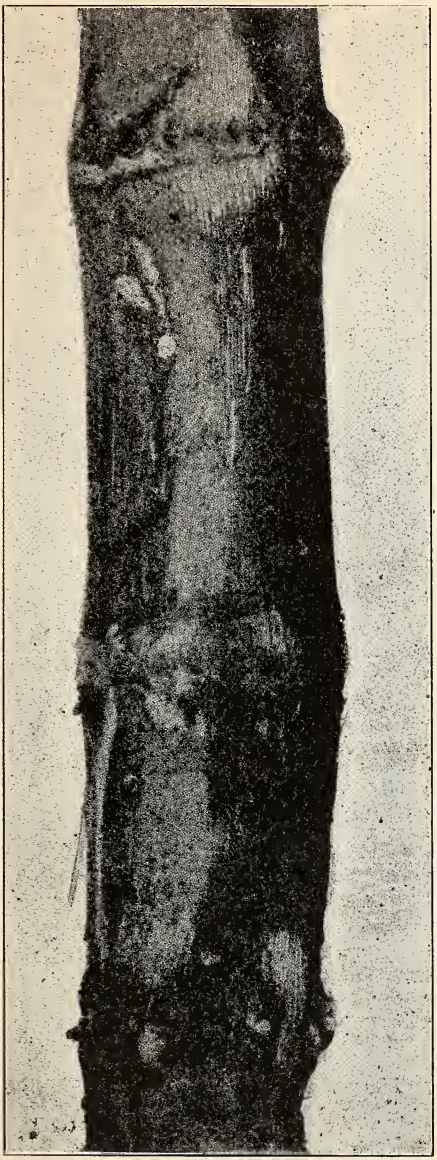

Fig. 19.—Corn stalk, showing holes made by corn stalk borers. (Photo. by the author.)

Corn is often injured by a caterpillar boring in the stalk, usually most noticeable and injurious when the corn is about half grown, but young plants may be destroyed. These borers weaken the stalks, retarding the development of the ears and sometimes render large stalks worthless except for fodder. These insects are said to be most abundant during the latter part of May or early in June.

DESCRIPTION AND HABITS.

Larvæ or Borers.—These burrowing caterpillars are about one inch long, with whitish, robust bodies, speckled with brown and black spots (Fig. 20). They confine their attack mainly to the three lower joints, and may occur without apparently affecting the growth. The larvæ, however, are very active, often leaving their burrows and making new entrance holes, thus severely weakening the stalks (Fig. 19).

Pupæ.—The pupæ, usually found in the stalk above ground, are of a shiny, brownish color and are about one-half inch long.

Parent Moths.—The adult moths have a wing expanse of about one and one-half inches; the fore wings are dull yellowish brown, or nearly

colorless; hind wings white or cream colored. The moths of the first brood appear in Georgia (where the writer studied this insect) from the middle of June to the middle of July. They probably appear about the same time in North Carolina.

LIFE HISTORY.

The reader will understand that there are two broods each season. The first brood are the progeny of the insects that pass the winter in the pupal stage, in corn stubble (presumably), while the second brood are the progeny of the moths that appear during June and July.

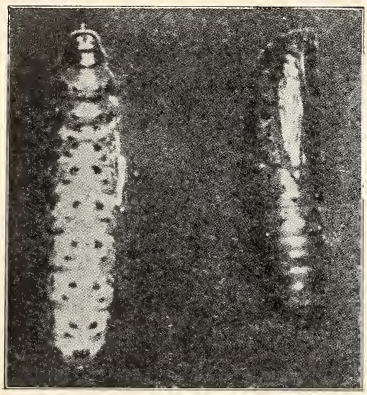

FIG. 20.—Larva and pupa of corn stalk borer. On left larva; on right, pupa—twice natural size. (Photo. by the author).

Corn is damaged most severely by the first brood, for at that time the plants are small or only partly grown. Late planted corn may be injured badly by the second brood. It seems highly probable that the corn stalk-borer has some wild host plants, some common weeds, in which many larvæ of the second brood mature. Howard[1] has reported its occurrence in Gama grass, and there must be other wild host plants. The insects pass the winter as pupæ, probably, to some extent at least, in corn stubble.

REMEDIAL MEASURES.

No truly effective remedy can be offered. It has been suggested that corn planted as late as May 15 to June 1 might escape injury, still it might also be attacked by larvæ of the second brood. When the stalk borers are observed the gardener should arrange to plow out, rake and burn the stubble as soon as the corn is harvested. Cutting the plants off at the surface of the ground will probably serve to trap nearly all the larvæ or pupæ that may be present, but such infested stalks should be fed to stock or hogs or used for ensilage. When corn is badly infested by stalk borers it would be best to use it for fodder or the silo, taking the precaution to cut the corn before many of the borers change to pupæ. The gardener can ascertain this point by frequently examining the corn plants for the presence of the brown pupa, which will certainly be found when the worms are full grown.

[1] Insect Life, Vol. IV.

Rotation of crops is of course beneficial, but it must be remembered that the moths are capable of flying some distance in spring in search of young corn in which to deposit eggs.

Deep fall or winter plowing of corn land may serve to bury some of the pupæ so that the moths can not escape.

Corn Ear Worm (*Heliothis obsoleta,* Fab.).

This insect does not by any means confine its attack to corn, though this is perhaps its favorite food plant. It may bore into cotton bolls, and is then known as the cotton-boll-worm. When it attacks beans, peas, tomatoes, okra, tobacco and other crops, it is generally known by the name of the plant on which it occurs. The wide variation in the color of the larvæ largely accounts for its having so many names.

DESCRIPTION, HABITS AND LIFE HISTORY.

The parent is a night-flying moth, the wings of which expand about one and one-half inches and range in color from dull yellow to olive green with black markings (Fig. 21). The moths that appear in early spring, having developed from pupæ that passed the winter in earthen cells, seem to prefer to deposit eggs on young corn, and later on the silk, particularly when that is present. The larvæ, small at first, grow rapidly, attaining a length of about one and one-quarter inches, and range in color from greenish to dark brown. The markings are shown in Fig. 22.

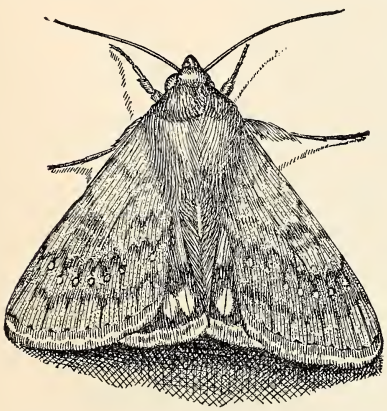

Fig. 21.—The Corn Ear-worm, showing adult moth in natural position with wings not spread —about twice natural size. (Quaintance, Bur. Ent., U. S. Dept. of Agr.)

Sweet corn is injured more severely than common field corn, but as the former is so much more preferable for table use the gardener should prepare to fight this insect.

There may be four or five broods each season, each successive brood gaining in numbers. When corn becomes hard, the moths deposit eggs on cotton, seeming to know instinctively that it will make better food for the larvæ.

REMEDIES.

The only direct remedy consists in pinching the tips of infested ears of corn to crush the larvæ within. A few rows of sweet corn may be treated in this manner. The pinching must, however, be done

several times and at intervals of only two to three days, as the small larvæ may escape.

Trap Plants.—Remembering that the moths prefer corn silk on which to deposit eggs, we have an opportunity of using a few hills of

FIG. 22.—The Corn Ear-worm, showing the destructive larva at work in ear of corn. (Quaintance, Bur. Ent., U. S. Dept. of Agr.)

very early planted corn as trap plants. Early maturing varieties should be used. The larvæ are cannibalistic, devouring each other when more than one are present in a single ear, hence the trap plant is peculiarly valuable. Trap plants must be watched and destroyed, or at least the worms destroyed before any become full grown and descend to the ground to pupate. Garden crops other than corn may be protected by having a few hills of corn in silk when the other crops would ordinarily be injured.

Winter Plowing.—As already stated, these worms usually appear

in cotton fields after the corn becomes hard, and hence it will be seen that the last generation is most liable to pass the winter as pupæ in such lands, rather than in garden or corn fields. Winter plowing of cotton fields, and gardens, where late corn has been grown, will kill many pupæ.

Corn Weevils *(Larvæ of Beetles and Moths).*

Stored corn, shelled or otherwise, is often infested with white grub-like larvæ, which may be the young of the rice-weevil *(Calandra oryzæ,* Linn.), or the granary weevil *(Calandra granaria,* Linn.), or the larvæ of the Angoumois grain moth *(Sitotroga cerealla,* Ol.). The latter is common, though the two former are better known. The two weevils are shown in Fig. 23, and the grain moth in Fig. 24. Corn may become infested with weevils in the field, but the grain moth is most liable to attack the stored corn.

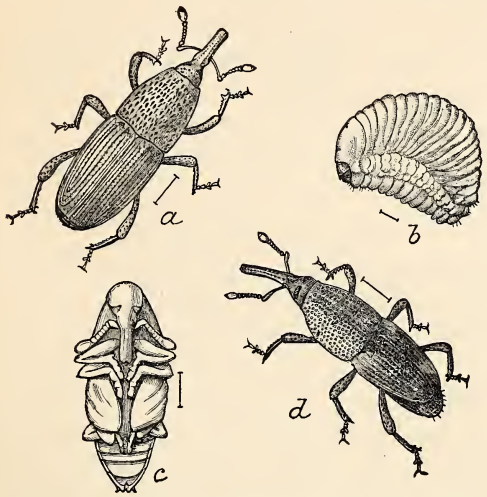

Fig. 23.—Corn Weevils: *Calandra granaria; a*, beetle; *b*, larva; *c*, pupa. *C. oryzæ, d*, beetle. All enlarged, (Chittenden, Farmers' Bul. 45, U. S. Dept. of Agr.)

As there is no known practical method of protecting the corn in the field we will not take space to describe these insects, but pass at once to the matter of remedies.

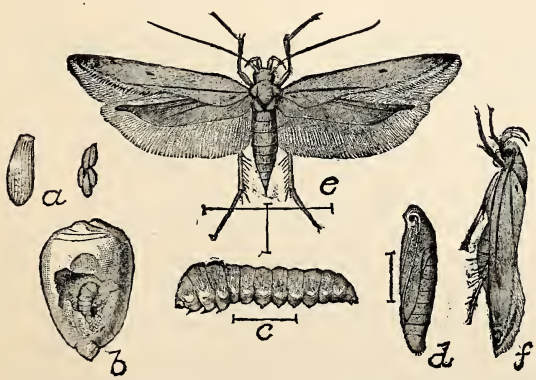

Fig. 24.—Angoumois Grain Moth: *a*, eggs; *b*, larva at work; *c*, larva; *d*, pupa; *e, f*, moths—all enlarged. (Chittenden Farmers' Bul. 45, U. S. Dept of Agr.)

REMEDY.

Fumigation.—Carbon bisulphid, a clear, foul smelling liquid that costs about 25 cents a pound is a certain remedy when properly used. Infested corn may be fumigated in *air tight bins* by using at least one and one-half or two pounds of carbon bisul-

phid for about one hundred bushels of grain. The grain moth is killed more easily than the true weevils, and for the latter it may be necessary to considerably increase the recommended amount. This remedy is often condemned and declared worthless because attempts made to fumigate the corn in loose, leaky bins have failed. It evaporates rapidly and the fumes are heavier than the air, so that they will settle and escape if any cracks are left in the bottom and sides of the bin or receptacle used for the fumigating chamber. The top must be closed or covered with something, such as wet blankets and boards, to keep out any currents of air. To fumigate, expose the liquid in shallow dishes near the top of the space, or pour it directly onto the corn, afterawrd leaving the place tightly closed for twenty-four to thirty-six hours. The fumes do not act immediately, like some other poison gases, and for this reason it is necessary to prevent even gradual leakage. When corn can not be treated in an *air tight* chamber, the amount of carbon bisulphid should be increased, but even then, under these conditions, the results may not be satisfactory.

Adult weevils and larvæ may be killed by fumigation except in certain cases when they are uncommonly well protected in the kernels, but as eggs which are not killed by fumigation may be present, it is generally necessary to repeat the treatment once or twice before corn is entirely freed from weevils.

Ordinary fumigation does not injure corn for eating or planting.

Caution.—The fumes of carbon bisulphid are highly combustible and explosive, hence lighted cigars, lanterns, etc., should not be brought near where the fumigation is going on. Breathing the fumes should be prevented, as they may cause a slight or severe headache. Some people are quite easily affected.

INSECTS AFFECTING CUCUMBERS AND CANTALOUPES.

Cutworms *(several species).*—(See under Insects Affecting Beans, p. 11).

Red Spider.—(See under Insects Affecting Celery, p. 31).

Melon Plant Louse *(Aphis gossipii,* Glov.).

Young cucumber, cantaloupe and similar plants may be attacked by small green sap-sucking lice that often cluster in great numbers on the under sides of the leaves. This same louse occurs on young cotton and is then known as a cotton louse. It is capable of causing severe stunting of growth and even death of badly infested plants. It occurs all through the summer months, sometimes injuring cantaloupes when the vines are several feet in length.

DESCRIPTION AND LIFE HISTORY.

Plant lice, of nearly all species, breed by giving birth to living young, the adults being both winged and wingless, as shown in Fig. 25. Many generations are developed each season and during the summer the colonies of lice contain no true males or females. This development is known as parthenogenesis, that is, the young are born by females without the intervention of the male. The melon louse is no exception to this rule. True males and females are developed by the last fall brood and the oviparous females deposit eggs to carry the insects through the winter. These eggs hatch in spring into minute lice that develop into viviparous females, whose young are born alive, as already explained.

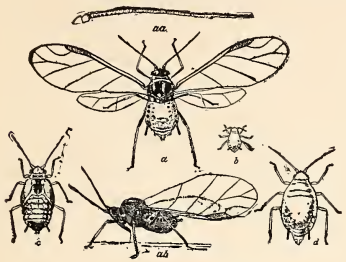

FIG. 25.—The Melon Aphis, *Aphis gossipii*: much enlarged. (Chittenden, Bur. of Ent., U. S. Dept. of Agr.)

The melon louse is yellowish green in color and about one-twentieth of an inch in length. The winged individuals of the colonies serve to spread the species, and their presence accounts for the isolated colonies that appear during the summer months. Individuals mature in six to eight days, and each gives birth to about fifty young. Considering this rapid increase it would seem that all infested plants would be destroyed, and such would be the case were it not for the valuable work of parasites, both internal and predaceous, that destroy great quantities of them. With these facts in mind, let us enter upon a consideration of the methods of control.

REMEDIES.

Spraying.—Contact poison sprays as used against cabbage lice (See p. 18) may be employed to kill isolated colonies that appear in spring.

Fumigation.—Within recent years a method of fumigating cantaloupe plants has been quite well perfected. Sanborn[1] has made valuable experiments with specially prepared tobacco or nicotine fumigating papers, manufactured and sold under the names nico-fume tobacco paper, aphis punk and to-bac-ine (See p. 64), and has perfected a system of fumigating by the use of cloth covered frames. The following description of a fumigating outfit is based on Sanborn's work:

Cloth Covered Frames.—For fumigating vines from two to four feet long construct a light wooden frame square or rectangular, of the desired dimensions, and nail an eight-inch leg to each corner. This may be covered with heavy muslin saturated with linseed oil to render

[1]Texas Expt. Sta. Bul. 89.

it air-tight. Cut the muslin in pieces large enough to cover the frame, and also extend one foot over each side, and tack to the top, but not to the legs of the wooden frame. The loose edges of the muslin may be covered with earth to prevent any escape of gas. A frame of this construction makes a perfect fumigating arrangement, as it can be placed over any portion of a long vine if desired without damage and without disturbing the vine.

Method of Fumigating.—Use the tobacco papers, as recommended (p. 64), fumigating the infested plants from 20 to 30 minutes. This will kill all the aphis under the frames without injuring the plants. This method is said to be comparatively cheap and it is undoubtedly effective, much more so in fact than the best spraying that could be done. By having several frames in operation one or two men may fumigate large areas in the course of a day.

Beneficial Parasites.—As already stated parasites render valuable aid in controlling the melon lice. In Texas, Sanborn has shown that it pays to induce the increase of parasites by planting Rape, which usually bear the cabbage lice in abundance. This plant furnishes food in fall for a number of predaceous parasites, such as lady-bird beetles and their larvæ, that feed on the cabbage lice, and the beetles hibernate during winter among the weeds and rubbish and thus are usually present in the spring and ready to attack the first broods of melon lice. Rape, as a trap plant, should be planted in summer and fall in the gardens or on the edge of the fields where cantaloupes and cucumbers are to be planted the following year.

Striped Cucumber Beetle *(Diabrotica vittata,* Fab.).

Here we have one of the commonest and most destructive of all insects that feed on the foliage of cucumbers and related plants. It is also a difficult one to control.

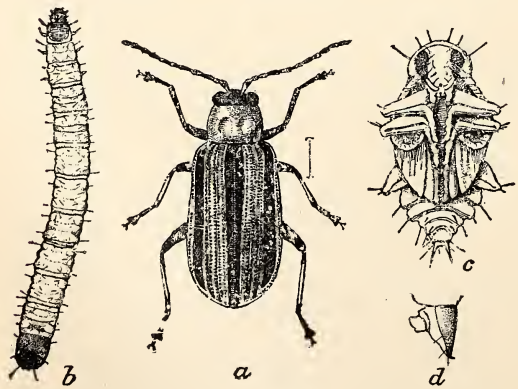

Fig 26.—Striped Cucumber Beetle: *a*, beetle; *b*, larva; *c*, pupa—all much enlarged. (Chittenden, Cir. 31, Div. of Ent., U. S. Dept. of Agr.)

Description and Life History.

Beetles.—These small, yellow winged beetles, only two-fifths of an inch long, marked with longitudinal black stripes on the wing covers (Fig. 26), usually appear early in the spring. They are voracious feeders and cause much damage to young plants. They hibernate during winter.

Eggs and Larvæ.—Eggs are deposited at the base of young cucumber plants and hatch into small, slender, whitish larvæ that feed on the tender rootlets. The larvæ may attain a size of about one-third inch. They cause plants to wither and sometimes die. Such injury is generally overlooked by gardeners or else is laid to cutworms. The larva matures in about one month, and after passing through the pupa stage, lasting about two weeks, the change to the adult takes place.

REMEDIAL MEASURES.

All plants subject to attack should be protected from the ravages of the beetles from the moment they appear above ground until several leaves are formed, after which the plants are better able to withstand the injury. This protection is best afforded by suitable covers, but certain repellent sprays and powders may be used with profit.

Cover Protection.—The cheapest and most effective protection is afforded by box frames, about one foot square, covered with fine wire or mosquito netting, or, in the manner sometimes suggested, by cutting a barrel hoop in two to form two semi-circles, and pressing these down, crossing each other over the plants and covering all with netting. The lower edge of the cover may be held down with earth. The writer believes that the perfect protection given by these covers, allowing the plants to grow for three or four weeks without injury, more than repays the cost of material and the trouble of fixing them in place.

Spraying and Dusting.—A combination repellent and poison in the form of Bordeaux-Paris green mixture (See p. 61) is the next best thing to a cover protection. The poison Bordeaux serves as a protection against the cucumber beetle, and all leaf eating insects that may be present, and furthermore serves as a fungicide to keep the foliage healthy. When liquid spray is used this is the most economical.

A dry mixture of lime and Paris green (See p. 60) will poison many beetles and also act as a repellent, and simply dusting plants with tobacco dust, kerosene and lime mixture, or hellebore offers considerable protection, but the liquid poison spray is the most efficient. Dry applications should be applied when plants are wet with dew and repeated after every shower.

Trap Plants.—A few *very early* planted cucumber plants liberally treated with poison spray may serve to lessen the number of striped beetles and also Flea beetles, 12-spotted Diabrotica (adult of corn rootworm) and all leaf eating insects present at that time.

Planting an excess of seed is advisable if the protective measures suggested can not be used. The plants should not be thinned out too

early, as some may die from the attack of the larvæ on the roots or from other causes.

Clean Culture.—Gardens should be cleaned up and all weeds and rubbish removed and burned during late fall or winter. This does away with the chance of leaving convenient hiding places in which this and many other garden insects may hibernate during winter. Fence rows should be cleaned out, and sod land adjoining gardens may be burned over to help destroy hibernating insects.

Cucumber Flea Beetle *(Epitrix cucumeris,* Harr.).

These small, black, jumping beetles (Fig. 27), about one-twelfth inch in length, often cause quite severe injury by eating the foliage of cucumbers, cantaloupes, melons, etc. The larvæ of this species is a leaf-miner, causing some damage, while the adults feed on the surface.

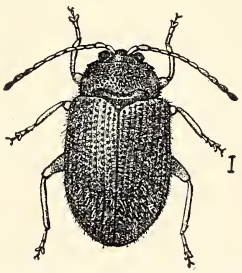

Fig. 27.—Cucumber Flea Beetle—much enlarged. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

Other Flea Beetles.—Several different species of flea beetles occur at times, and injure cabbages, turnips, potatoes, beans and many garden plants. The larvæ of most species feed on the roots of Jimson or other common weeds. The beetles all get their name from their ability to jump, due to thickened and muscular hind legs like those of the grasshopper.

REMEDIES.

Protective covers, poison and repellent sprays, and powders, and in fact all methods of control suggested above against the striped cucumber beetle are effective against flea beetles.

Pickle Worm *(Diaphania nitidalis,* Cramer).

Growers of cucumbers and cantaloupes need no introduction to this troublesome pest that bores into cucurbits, rendering them unfit for table use or for market. The injury is caused by the larvæ. This borer is frequently called the melon worm or cantaloupe worm, but we will consider it as the pickle worm because a closely related species is now known as the melon worm. (See p. 57).

DESCRIPTION.

Eggs and Larvæ.—The eggs are generally laid in masses in blooms or tender buds. They are at first white, but change to yellowish green before hatching into small whitish worms. When grown the larvæ are yellowish green in color, about three-fourths of an inch long, and have eight pairs of legs.

Pupæ.—Light silken cocoons are spun in a fold of a leaf of the food plant, or on weeds close by, and here the pupæ are formed, changing later to adult moths.

FIG. 28.—Pickle Worms working on cucumber. (Quaintance, Bul. 45, Ga. Exp. Sta.)

Parent Moths.—The moths have a wing expanse of about an inch; the color is yellowish brown, marked with yellow areas. The body terminates in a prominent brush like that of the melon worm (Fig. 37).

LIFE HISTORY AND HABITS.

The average life cycle of the pickle worm was determined by Quaintance[1] in 1901 as being from 24 to 27 days, showing that there may be at least four or more broods each year. The winter is passed in the pupal stage, always above ground in weeds or rubbish, which allows the gardener a chance of destroying great numbers by clean culture. The moths are nocturnal, hiding during the day. It seems that the first ones emerging from the over-wintering pupæ are somewhat late, appearing when the cucumbers or cantaloupes are well started into growth. The young larvæ may feed in opening buds, or at the base of the leaves, but soon attack the fruit. The greatest injury of course comes from their boring into the fruit, this being exaggerated by their habit of passing from one fruit to another. A great preference is shown for the blooms of squash (Fig. 29), and this may be made use of in protecting the cantaloupes and cucumbers as stated under remedies.

REMEDIAL MEASURES.

Very early planted cucumbers and cantaloupes for home or market use may escape injury from this pest, owing to the late appearance of the moths. Late plantings may be seriously injured, and there seems

[1] Georgia Expt. Sta. Bul. 54.

to be no absolute remedy to suggest. Trap crops, clean culture, and poisoning will all help to lessen the injury.

FIG. 29.—Pickle Worms feeding in squash blooms. (Quaintance, Bul. 45, Ga. Exp. Station).

Poison.—Dusting young plants with lime dust and Paris green may serve to poison some young larvæ that feed in the buds and flowers before entering the fruit.

Trap Crop.—Squash plants started early and planted among and near the crop to be protected are of great value if properly managed. The pickle worm larvæ feed freely in the squash blooms, and when this plant is used as a trap the infested blooms must be regularly gathered at least once a week and carefully destroyed to prevent any larvæ from maturing. Quaintance found that this crop offers very great protection, and when adopted squash seed should be planted every two or three weeks in order to furnish an abundance of blooms while the cucumbers and cantaloupes are developing. The squash plants might be poisoned also as a further protection.

Destroying Infested Fruit and Over-wintering Pupæ.—All infested fruit should be gathered and fed to hogs or otherwise destroyed to kill the larvæ within. As soon as the crop is gathered, rake up and burn the vines, together with all weeds and rubbish, to destroy any larvæ and pupæ that may be present. Deep plowing directly after the crop is gathered will no doubt stop further increase, and as another safeguard it is best to practice rotation of crops.

INSECTS AFFECTING THE EGG-PLNT.

Egg-plants are not subject to serious injury from insect attack, but some minor damage may occur each year. Some insect pests that may be expected are mentioned below:

Aphis (Plant Lice).—(See under Cabbage Aphis, p. 17).

Colorado Potato Beetle.—(See under Potato Insects, p. 49).

Cutworms.—(See under Bean Insects, p. 11).

Flea Beetles.—(See under Cucumber Insects, p. 44).

Harlequin Bug.—(See under Cabbage Insects, p. 18).

INSECTS AFFECTING THE ONION.

Cutworms.—Onion sets are liable to be seriously thinned out by cutworms, hence land on which onions are to be set should be carefully prepared, and freed as far as possible, from these pests by the use of poisoned baits as recommended on p. 12. When onions are grown in the field from seed an abundant supply should be planted to insure a stand, but the use of poisoned bait previous to sowing the seed should not be neglected.

Onion Maggot *(Pegomyia ceparum,* M.).

When plants in the onion beds commence to turn yellow, wilt, and die, from no apparent exterior cause, white maggots in the roots may be looked for.

As the life history and habits of this insect are so nearly the same as the cabbage maggot, the reader is referred to the description on p. 28.

Remedy.—In addition to the remedies suggested against cabbage maggots, gardeners may make good use of a carbolic acid emulsion, recommended by Slingerland,[1] whose formula is as follows:

Dissolve one pound of soap in one-half gallon of water, and thoroughly emulsify with one pint of crude carbolic acid. For use take one part of the emulsion to fifty parts of water.

This emulsion should be applied with a spray pump around onion plants, after first removing the surface soil. It is said to kill the maggots and also repel the parent fly from laying eggs.

Unleached ashes scattered over the beds just after the onions have come up is also said to repel the parent flies.

Infested fields should not be planted to onions the following year, and new seed beds should be placed as far away as possible.

INSECTS AFFECTING PEAS.

Pea Weevil *(Bruchus pisorum,* Linn.).
(And Other *Bruchus* spp.).

Belonging to the same genus as the Bean Weevil, but differing considerably in life history, the pea weevil *(B. pisorum)* is a common

[1] N. Y. Cornell Expt. Sta. Bul. 78.

pest in stored peas. This species is a little larger (Fig. 30) than the bean weevil described on p. 15 and illustrated in Fig. 7. They differ materially, however, in the number of annual generations, for the pea weevil has only one, while the other may have several. Furthermore, only one larva of the pea weevil invades a single pea, and always gains entrance while the peas are green in the field. In other words, the pea weevil does not breed in dried peas, like the other species that have been mentioned.

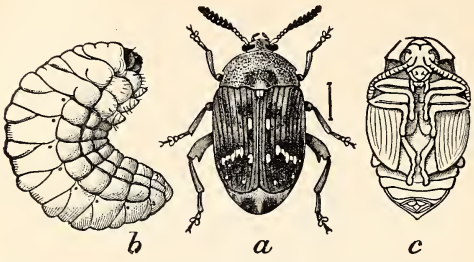

FIG. 30.—Pea Weevil, *Bruchus pisorum: a*, beetle; *b*, larva; *c*, pupa—much enlarged. (Chittenden, Yearbook, 1898, U. S. Dept. of Agr.)

The 4-spotted bean weevil (Fig. 8) may infest peas or beans, and unlike the common pea weevil, this species will breed in dried peas, producing successive generations like the bean weevil, hence any remedy against pea weevils must be one that will destroy all species present.

REMEDIES.

Fumigation.—If only the pea weevil *(Bruchus pisorum),* that does not attack dried peas, were present, fumigation of peas would not be necessary. Simply placing them in perfectly tight receptacles until the adult weevils died would be sufficient. This condition may not occur, however, so we must prepare to fumigate to kill weevils whenever present.

Fumigation is the best remedy known, and carbon bisulphid is the material usually used. This clear, colorless, foul smelling liquid will kill the weevils, both larvæ and pupæ, but not the eggs. It is used, at the strength of one teaspoonful to a cubic foot of space, by placing the infested beans or peas in a perfectly air-tight receptacle, such as a large earthen jar, exposing the liquid on top in a shallow dish, and leaving the chamber closed for twenty-four hours. The liquid soon evaporates and the fumes, which are heavier than air, readily penetrate to the bottom.

Much loss might be prevented if gardeners would practice fumigation of peas and beans when first stored, but even when that is done they should be treated again if any weevils are observed later. As several broods may develop and weevil eggs may be present almost any time, fumigation must usually be repeated two or three times. The reader should refer to p. 40 for further information about carbon bisulphid and precautionary measures to be observed.

Uninfested peas or beans, if stored in perfectly tight receptacles, will remain free from weevils.

To insure getting good seed for planting, pour them in water, when the infested ones will float and may be discarded.

INSECTS AFFECTING IRISH POTATOES.

This valuable vegetable is subject to the attack of leaf-eating insects, such as Colorado Beetles, Flea Beetles, etc., and the tubers may be damaged by wireworms and white grubs. These pests, together with the stalk borer and others, must be fought successfully if potato growing is made profitable.

Colorado Potato Beetle *(Leptinotarsa 10-lineata*, Say.).

This common potato pest is well known and frequently referred to as the potato bug, though the name beetle is more appropriate. It has been given the name Colorado potato beetle because of its being native to Colorado, where it formerly fed upon wild weeds belonging to the same genus as the potato plant. The Irish potato seemed to be much preferred by this insect, and when that vegetable was introduced it was speedily attacked.

Colorado potato beetles were first seriously injurious to potatoes in 1855, in Colorado, and since then have spread to the East and North, until now they occur in practically all of the potato growing sections of the United States and Southern Canada. Its natural spread was undoubtedly hastened by the parent beetles being shipped with potatoes. At the present time it appears to be omnipresent, for the potato patch can not be located where the beetles may not appear. For this reason the practice of rotating crops, so beneficial against certain other insects, does very little good in this case.

DESCRIPTION AND HABITS.

Parent Beetles.—It has been said that these beetles perch themselves on clods of earth and await the sprouting of potatoes in spring. This is almost literally true, for the adults pass the winter in protected places, and are among the first to appear in spring.

The beetles are ochre-yellow in color, with ten longitudinal black lines on the wing covers (Fig. 31). They do considerable damage by feeding on the foliage.

Eggs.—The eggs are deposited in flat clusters of fifty or more, on the under sides of the leaves. They are conspicuous orange colored. Each female may lay from six hundred to one thousand eggs.

Larvæ or "Bugs."—The soft bodied, reddish, hump-backed creatures, commonly called bugs, are voracious feeders, causing much

more damage than the adults. In four to five weeks, they attain full growth after eating an enormous quantity of food, and then drop from the plants, enter the earth and form a smooth, oval cell (Fig. 31).

FIG. 31.—Colorado Potato Beetle: *a*, eggs on leaf; *b*, small and grown larvæ; *c*, pupa; *d*, adult beetle; *e*, enlarged wing-case of adult; *f*, enlarged leg of adult. (Riley, Missouri Reports).

Pupæ.—In the earthen cells the pupæ pass a motionless life for ten days to two weeks, and then transform to the parent beetles.

Generations.—There are probably four generations each year in North Carolina, the last beetles passing the winter in hibernation.

REMEDIES.

The voracious feeding habits of this pest, coupled with the power of the potato plant to withstand arsenical poisons, offers us a reliable remedy in the poison applications.

Arsenicals.—Paris green or arsenate of lead applied as a liquid spray is a perfect remedy. The former may be used at the greatest strength recommended on page 60 and the latter at the usual strength.

Dry Paris Green Mixture (See p. 60) may be dusted on while wet with dew or just after a rain by means of a good powder gun, or through a cloth sack, or a tin can with the top perforated like a pepper shaker. These poison applications will certainly control the Colorado potato beetles, but the grower should watch carefully for the first appearance of egg masses, and then be prepared to apply the poison to kill the young larvæ before the plants are defoliated. It is just as easy to poison the bugs before the foliage is injured—and certainly more economical.

No Danger From Arsenical Sprays on Potatoes.—The writer has met a few people who feared to apply the Paris green to potato plants,

thinking that the tubers would absorb the poison from the foliage. There is absolutely no such danger, and practically no danger to the persons applying the poison.

Bordeaux Mixture and Paris Green.—We would particularly advise the use of Paris green in Bordeaux mixture (See p. 61), as it helps to keep the plants free from disease, and the poison so applied is not readily washed off by rains. Arsenate of Lead may be applied in the same manner.

Three-lined Leaf Beetle *(Lema 3-lineata,* Oliv.).

This somewhat common potato pest is closely related to the Colorado beetle, but differs in size and color. The beetles are about one-fourth inch long, yellow in color, with three black stripes on the wings, resembling the striped cucumber beetles mentioned on p. 42. The larvæ are dirty yellow and may be recognized by the habit of covering the body with their own excrement. The eggs are orange colored, usually laid in rows along the mid-rib on the lower sides of the leaves.

When present these insects may be controlled by the remedies suggested against the Colorado beetle.

Flea Beetles *(Several Species).*

These small jumping beetles, usually black in color, riddle the leaves with small holes, but their work may be prevented by thoroughly spraying the plants with Bordeaux and Paris green mixture. The cucumber flea beetle, mentioned on p. 44, often attacks the potato plant. Poison dust sprays act both as a repellent and poison to these little creatures.

Potato Stalk Borer *(Trichobaris trinotata,* Say.).

As its name implies, the insect lives in the larval or grub stage in the stalk, boring through the heart, and when several are present, they severely weaken and generally kill the infested plants. The presence of only one or two is seldom noticed.

DESCRIPTION AND HABITS.

Adult.—The parents of the stalk borers are small, greyish weevils, about one-sixth inch in length, and having a strong, curved snout. They hibernate during winter, usually appearing early in spring to deposit eggs in the potato stalks. Otherwise they cause no apparent damage.

Larvæ.—Usually called grubs, are white or yellowish in color with brown, horny heads, and attain a length of about one-half inch. When grown they change to pupæ in cocoons in the stalk.

Life History.—There are two generations each season, the adult of the first appearing about the middle of July, while the adults of the later brood appear during August or September, and hibernate during winter. (See Fig. 32 for illustration of this insect.)

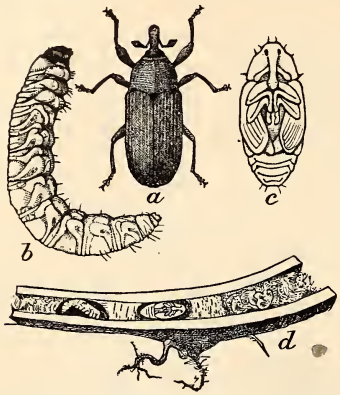

FIG. 32.—Potato Stalk Borer: *a*, beetle; (weevil); *b*, larva (borer); *c*, pupa—five times natural size; *d*, section of potato stalk opened to show larva and pupa *in situ*. (Chittenden, Bul. 33, Bur. of Ent, U. S. Dept. of Agr.)

REMEDIAL MEASURES.

It appears impossible to suggest a direct method for killing the borers in the stalks without destroying the plants, hence every effort should be directed toward keeping them from reaching the adult beetle stage, and thus prevent them from being numerous during the succeeding season. Infested plants, detected by their wilted appearance, should be pulled up and burned. After the potato crop is gathered all vines in the infested fields should be raked together, dried a few days, and then burned.

It is known that this borer breeds in the stem of the egg plant and wild plants, such as horse nettle, bull nettle, jimson weed, and many *solanaceous* plants. When these occur around infested potato fields they should be cut and burned, if possible, while the borers are in the stems, and thereby prevent the development of beetles.

WHITE GRUBS OR GRUBWORMS.

We will discuss white grubs under the head of "Potato Insects," though in reality they are often as injurious, and sometimes more so, to strawberries, corn, small grains and many tuberous rooted vegetables such as beets, turnips, etc. In fact most garden crops are injured at times by white grubs, which are more or less common in all localities. It is evident that these insects formerly subsisted on grass roots in the wild prairie lands, being native to this country, and turned their attacks to cultivated crops when deprived of their natural food by the cultivation of lands in which they lived. There are a large number of species of white grubs, some being feeders on decaying vegetable matter, manure, etc., and hence not injurious, while others subsist on the roots of growing plants.

GENERAL DESCRIPTION.

White grubs, in general, may be described as having thick bodies, and hard, horny heads, behind which are three pairs of true legs end-

ing in claws, while their abdomens are usually distinctly enlarged near the caudal ends (Fig. 33, e). They lie in a curved position, as shown in the figure. Some species get to be nearly two inches long,

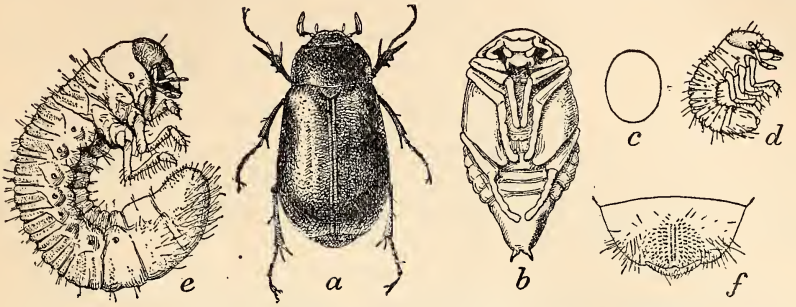

FIG. 33.—White Grub, *Lachnosterna arcuata: a*, beetle; *b*, pupa, *e*, larva—all enlarged one-fourth. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

while many are smaller. Practically all the most injurious forms belong to the genus *Lachnosterna.*

Parent Beetles.—The parents are called May or June beetles, mostly shining brown in color and quite large, being known by their habits of flying into houses attracted by the lights at night. The beetles occasionally cause much injury to pecan trees and fruit trees by eating the developing buds.

LIFE HISTORY AND HABITS.

The eggs are deposited in sod lands, weedy places, strawberry beds, especially if the latter are weedy, and young grubs feed on the roots of almost any available plants. The eggs are laid from May to July, and the grubs require from two to three years to mature, this depending on the species.

It will be seen that land once infested may remain so continuously, and when disturbed by plowing, destroying the crop, strawberries, grass or whatever was on the land, the grubs must feed on the roots of the crops following. If potatoes are planted on sod land or old strawberry beds, they are liable to be seriously damaged by these insects, and the same would be true of most other vegetables.

When mature, the grubs transform to pupæ in earthen cells, and about August or September change to the parent beetle, which may remain in the cell all winter.

REMEDIES AND PREVENTION.

Insecticides.—These are not practicable in the writer's opinion, though liberal applications of Gas Lime or kerosene emulsion have been used on lawns with some success.

Rotation.—This is another case where an ounce of prevention is

worth a pound of cure. Land known to be infested with white grubs should be sown in clover or some crop least liable to be injured by these insects, at least two years before planting in potatoes or any other tuberous vegetable. Corn land is liable to be infested, and here rotation is valuable. Sod land should never be planted to vegetables the first year after plowing. The rotation should be planned so that the land may be thoroughly plowed each fall or winter.

Fall Plowing.—This will undoubtedly kill some grubs by exposing them as prey to birds and fowls and by leaving them exposed to the winter's cold. By following fall plowing with a cross plowing or harrowing during winter when the condition of the land will permit, better results will be obtained.

Domestic Animals.—Chickens and turkeys should be encouraged to follow the plow, as they will pick up great numbers of all kinds of insects. Hogs delight to root for white grubs, and if turned into the garden and encouraged to root by scattering a little corn on the ground, they will render valuable service.

INSECTS AFFECTING THE SQUASH.

Squash Bug (*Anasa tristis*, DeG.).

Here we have another injurious sucking insect, and one that seems to inject a poison into the plant the same as as is the case with the Harlequin bug on cabbage. The name stink-bug is often applied to this insect, and to several related forms because of their disagreeable odor.

DESCRIPTION AND HABITS.

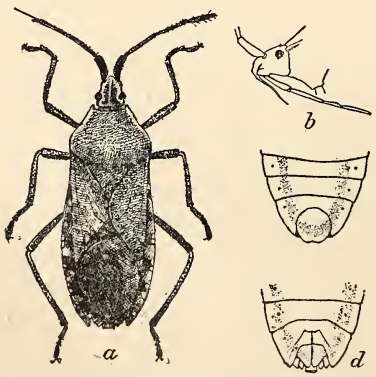

Fig. 34.—Adult Squash Bug: Twice natural size. (Chittenden, Bul. 19, Bur. of Ent., U. S. Dept. of Agr.)

Adult Bugs.—These bugs are very generally known, but may be briefly described as being a little over one-half inch long (Fig. 34), dirty blackish brown above, and mottled yellowish beneath, the head bearing a long jointed beak that lies between the legs when not in use. They are nocturnal in their habits, and hide during the day under sticks, leaves, etc.

Eggs and Nymphs.—The brownish eggs are laid in irregular rows on the leaves, and hatch into small awkward looking creatures. These young, called nymphs, generally feed for a time in groups, and increase in size by successive molts, gradually developing wings. A

dozen nymphs may seriously injure a small squash or melon plant, by the combined effect of loss of sap and poison injected.

Life History.—The adult squash bugs pass the winter in protected places, under rubbish in or about the gardens, or in fence corners, etc., appearing early in spring to deposit eggs. There may be several generations each year.

REMEDIES AND PREVENTION.

Hand Picking.—The first bugs appearing in spring may be collected by hand to prevent their depositing eggs. This practice is advisable all through the spring and summer, when plants are not otherwise protected.

Cover Protection.—Young plants may be protected by methods recommended on p. 43 under Cucumber Insects.

Trapping.—Trap plants started very early, planted indoors in strawberry baskets, if desired, and transferred to the garden, will be found very valuable. The bugs will collect on such plants and may be picked off by hand together with the egg masses. Bugs may also be trapped at all times under shingles, boards, or cabbage leaves. After feeding at night, they will hide under these traps, from which they should be collected each morning, particularly during early spring.

Spraying.—Poison sprays are obviously useless against this sucking insect, but kerosene emulsion of a strength of 10 per cent will kill the young nymphs when feeding in groups. Repellent sprays or powders (See p. 43) are of some value.

Clean Culture.—Burning all rubbish and old plants, both after the crop is gathered and during fall or winter, will do much toward preventing the adult bugs from hibernating successfully.

Squash Vine Borer (*Melittia satyriniformis,* Hbn.).

Damage from this insect is caused by the larvæ boring into the stalk, sometimes resulting in death of the infested stalk, and always causing a loss of vitality. Squash and pumpkin are the favorite food plants, but melons and cucumbers may be attacked.

DESCRIPTION.

Parent Moths.—The moths as described by Quaintance[1] have forewings opaque, shining olive brown in color, and transparent hind wings bordered by a narrow fringe of scales. The body is about three-fourths of an inch long, with a wing expanse of nearly one and

[1] Georgia Expt. Sta., Bul. 45, p. 47.

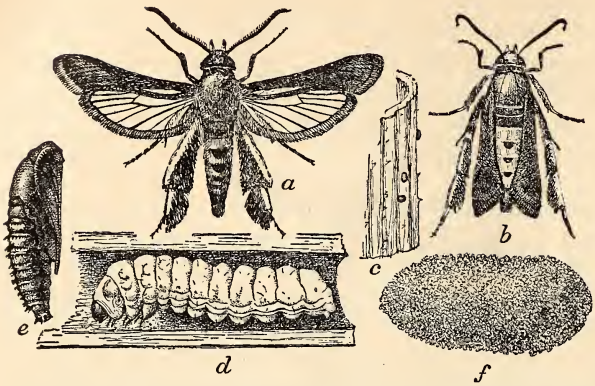

FIG. 35.—Squash-Vine Borer. *a*, male moth; *b*, female moth, wings folded; *c*, eggs on stem; *d*, larvæ; *e*, pupa; *f*, pupa cell—all one-third enlarged. (Chittenden, Cir. 38, Bur. of Ent., Dept. of Agr.)

one-fourth inches (Fig. 35, enlarged).

Larvæ and Pupæ.—The borers are about one inch long, whitish in color and grub-like in form. When grown, they leave their burrows and spin tough silken dirt covered cocoons (Fig. 36) near the base of the plant from which they emerged. In this cocoon the larva changes to a pupa and eventually to an adult moth, which escapes through the end, as illustrated in Fig. 36.

LIFE HISTORY.

Observations on the life history of this insect, made in Georgia by the writer, showed that the pupæ stage was from three to four weeks, and that adults of the first brood appeared about the last of June. The second and last generation pass the winter in cocoons, changing to moths in spring about the last of April. These dates are probably a little too early for North Carolina conditions.

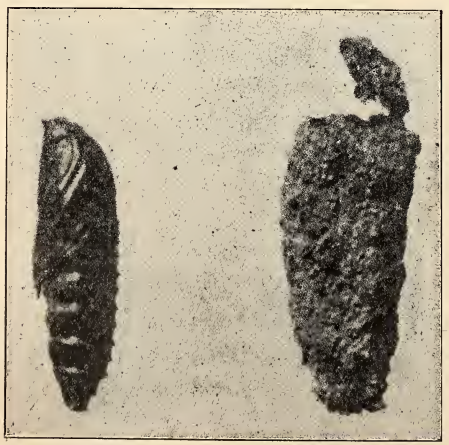

FIG. 36.—Pupa and empty cocoon of squash-vine borer—twice natural size. (Photo. by the author.)

TREATMENT.

The presence of borers may be detected by the accumulations of yellow excrement, cast out from the burrows about the base of the plants. Early in June this is frequently quite noticeable, and, when detected by the gardener, the borers should be carefully searched for and removed. This may be done without much additional injury to the plants, and is the only

direct remedy. The borers of the first brood should be destroyed if possible.

After the crop is gathered the vines, root and all, should be pulled and burned to destroy any borers that might be within. As some borers of the second brood are liable to form cocoons before the plants are removed, deep fall plowing is advisable. This, coupled with prompt destruction of infested plants before the borers escape, should keep the pest reduced to insignificant numbers.

Melon Borer (*Diaphania hyalinata*, Linn.).

Closely related to the borer known as the pickle worm, described on p. 44, this destructive pest causes much damage by eating off the soft rind and boring into the squash, melon, etc. It differs from the pickle worm mainly in the habit of eating the foliage more freely and is therefore more easily controlled.

DESCRIPTION.

Parent Moths.—This is quite a beautiful moth described by Quaintance[1] as having wings of pearly iridescent whiteness, with a border of brownish black. The body color is white and brown, and the abdomen terminates in a large movable brush of elongated scales. The body is about three-fourths of an inch long and wings expand about one and one-fourth of an inch (Fig. 37, enlarged).

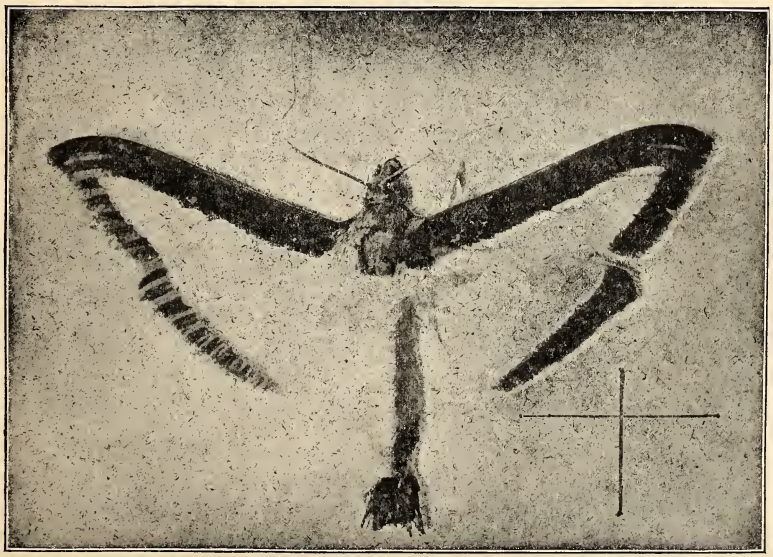

Fig. 37.—Moth, or parent of the Melon Worm: Much enlarged. (Quaintance, Bul. 45, Ga. Expt. Sta.)

[1] Georgia Expt. Sta., Bul. 45, p. 45.

Eggs and Larvæ.—Eggs are placed singly on the lower surface of the leaves, and hatch into active caterpillars, which when grown are slightly longer than pickle worms. They are of a pale greenish yellow color and possess a black head.

LIFE HISTORY AND HABITS.

The life history of this borer is nearly the same as the pickle worm. The greatest difference in habit is that of feeding on the foliage more than the pickle worm, and this gives the gardener an opportunity to make use of poison sprays. The melon borer seems to thrive best during rainy seasons.

REMEDIES.

Spraying is quite effective against the young borers that feed on the foliage. Paris green-lime mixture, Bordeaux-Paris green mixture, or arsenate of lead may be used. The gardener should watch carefully for the first brood of melon worms and be prepared to use the arsenical sprays quickly and thoroughly. Infested fruit should be fed to hogs or otherwise destroyed.

All the preventive measures recommended on page 45 against the pickle worm should be used against the borer, except the method of using squash blooms as traps.

INSECTS AFFECTING TOMATOES.

Cutworms.—(See under Bean Insects, p. 11).

Flea Beetles.—(See under Potato Insects, p. 51).

Potato Beetles.—(See under Potato Insects, p. 49).

Tomato Fruit Worm *(Heliothis obsoleta).*

This is the same as the corn ear worm and the cotton boll worm. Under Corn Insects, p. 37, the reader will find a full description and also cultural methods of control. It is true that this is a difficult pest to fight, unless the gardener will study the habits of the worm, and learn how best to make use of corn as a trap crop, for there is no good remedy except to pick them off by hand. Corn as a trap crop, unless properly managed so as to destroy the worms that attack it, may serve only to increase the numbers of this pest.

Thorough spraying of tomato plants with Bordeaux-Paris green mixture, usually used against flea beetles and the green tomato worm, may result in poisoning some of the fruit worms. This should not be depended upon, however, for the worms eat only a small area of the surface of tomatoes.

Tomato Horn Worm (*Phlegethontius celeus,* Joh.).

This conspicuous green worm is sometimes abundant enough to cause noticeable injury and occurs also on tobacco, and on that plant it is a very serious pest. This is the larvæ of a large, narrow-winged moth, belonging to the family *Sphingidæ* or Sphinx Moths.

Fig. 38.—Tomata Horn Worm, *Phlegethontius celeus: a*, adult moth; *b*, full-grown larva; *c*, pupa—about two-thirds natural size. (Howard, Farmers' Bul. 120, U. S. Dept. of Agr.)

DESCRIPTION.

Larvæ.—Full grown worms are from three to four inches long, dark green in color, with oblique V-shaped white lines on each side of the body. The caudal end bears a prominent, long, sharp-curved horn that is quite characteristic. A closely related species of horn-worm, having straight white oblique lines on each side of the body is almost equally common.

Moths.—The moths have large, powerful wings, narrow compared to their length, and a robust body. The wings are brownish gray in general color with wavy markings and expand about four inches. The abdomen is marked on each side by five orange colored spots bordered with black.

REMEDIES.

Small fields of tomatoes, or especially a few garden plants, may be protected by picking the worms off by hand. Arsenical poison sprays used in connection with Bordeaux mixture is advisable, for this latter is of great value alone as a fungicide. Arsenical sprays may be used up to within ten days of the time the fruit ripens without danger of poisoning persons who eat the tomatoes.

FORMULAS AND DIRECTIONS FOR PREPARING SPRAY MIXTURE.

FOR BITING INSECTS.

Paris Green (as a liquid spray).

Paris Green	1 pound
Lime	2 pounds
Water	100 to 200 gallons
Or Bordeaux mixture	100 to 150 gallons

(See formula, next page.)

To prepare.—The combination of Bordeaux mixture and Paris green is often preferable to the simple water mixture with lime; but no matter what is used as a carrier for the poison, it should first be made into a thin paste with a small amount of water. This will prevent lumping and insure an even distribution of the poison in the mixture. When Bordeaux is used it is unnecessary to employ the extra two pounds of lime, but this should always be added to the simple water mixture. The lime unites with any free arsenic that may be present in Paris green, preventing burning of foliage that might otherwise occur.

Paris green, if absolutely pure, is entirely insoluble in water, but most commercial grades contain some water-soluble arsenic, the burning effect of which is overcome by lime. Paris green is really a very fine crystalline powder, and must therefore be held in suspension by constant agitation.

Plants with tough resistant foliage like potatoes and cabbage may be sprayed with one pound Paris green in 100 gallons of water, but tender plants such as tomatoes, beans, and celery, should be given a more diluted mixture.

Paris Green (in dry form).

Mix with from ten to fifty parts of cheap flour, land plaster, sifted air-slaked lime, ashes or fine dust and dust evenly over the plants by means of a cloth sack, pepper shaker arrangement or dusting machine.

Green Arsenoid.

This is often substituted for Paris green, and may be used in the same proportion, but should never be used as a liquid spray without the addition of lime. Green arsenoid is lighter in weight, not crystalline in form, and remains in suspension longer than Paris green, but otherwise it has no advantage unless it can be purchased at less cost.

Arsenate of Lead.

Acetate of Lead *(Sugar of Lead)*.....11 ounces
Arsenate of Soda..... 4 ounces
Water .....50 gallons

This is a formula for home-made arsenate of lead, prepared by dissolving the acetate of lead in one gallon of water, and the arsenate of soda in two quarts of water in a separate vessel. It is best to use wooden buckets. When the two solutions are poured together a fine, white precipitate is formed. This makes a stock solution ready to dilute with 50 gallons of water.

The advantages of arsenate of lead over Paris green and green arsenoid are: (1) greater adhesive quality; (2) remains in suspension with very little agitation; and (3) seldoms injures foliage. It is generally claimed that it will not burn or injure the tenderest foliage, but this is not true, although it is perfectly safe to use on most garden vegetables.

Arsenate of lead is now manufactured rather extensively and is put up and sold as a dry powder or paste. At wholesale prices the manufactured product is about as cheap as that prepared at home, and somewhat preferable, because of its always being ready to mix with water.

Bordeaux Mixture and Arsenicals.

Bordeaux mixture.....50 gallons
Containing one of the following:
Paris Green.....1-3 to 1-2 pound
Arsenate of Lead.....3 pounds
Green Arsenoid.....1-3 to 1-2 pound

It is frequently desirable to use arsenicals in Bordeaux mixture because, in addition to killing the insects, the plants should be protected from leaf diseases. Bordeaux mixture is a great help towards keeping plants healthy. Furthermore, the poison is made to adhere longer, and is very much less liable to injure the foliage when used in this manner.

Bordeaux Mixture.

Bluestone (Copper Sulphate).....4 pounds
Lime, fresh unslaked.....6 pounds
Water .....50 gallons

To prepare.—Dissolve the bluestone in 25 gallons of water in one receptacle, and slake the lime in another, and dilute to 25 gallons. Do not pour the solutions directly together, but take a bucketful of each and pour these simultaneously into a barrel or spray tank. As

the solutions unite a fine blue precipitate is obtained, and the resulting mixture will not settle as rapidly as when the two solutions are mixed by pouring one directly into the other.

Many writers advocate making Bordeaux for general use with 6 pounds of bluestone and 6 pounds lime, but this is apparently stronger than is necessary, and at the present price of bluestone, is rather expensive.

Adhesive Resin Wash.

With a few plants, like cabbages and collards, which have very smooth foliage, difficulty is often experienced in making poison mixtures adhere. To overcome this difficulty, the following is suggested:

Stock Solution	Pulverized Resin	5 pounds
	Concentrated Lye	1 pound
	Fish Oil	1 pint
	Water	5 gallons

To prepare.—Place the oil and resin in one gallon of water and boil until the resin is thoroughly softened. Dissolve the lye in a separate vessel and add slowly to the resin mixture, stirring constantly until well mixed. Then add four gallons of water and continue the boiling until the resulting mixture will mix readily with cold water.

DIRECTIONS FOR USING.

Resin Mixture *(Stock Solution)*	1 gallon
Water	16 gallons
Milk of Lime (2 pounds unslaked lime)	3 gallons
Paris Green or Green Arsenoid	1-4 pound

To prepare.—Add water to the stock solution and mix thoroughly; then add the milk of lime, and then the Paris green or green arsenoid. The order of mixing should not be changed, or a heavy precipitate will form that will clog the spray pump and nozzle. The stock solution may be kept on hand, but the diluted mixture must be freshly prepared when used.

Hellebore.

Hellebore acts both as an internal and contact poison. It is used against soft-bodied caterpillars, such as cabbage worms, in liquid form, 1 ounce in 3 gallons of water; or mixed, dry, with four parts of cheap flour or road dust. It loses its strength when exposed and must be applied every two or three days as long as the worms are present. This is not very valuable for use except on vegetables that are nearly grown.

FOR SUCKING INSECTS.

Kerosene Emulsion.

Stock Solution.

Hard Soap	1-2 pound
Or Soft Soap	1 quart
Water	1 gallon
Kerosene	2 gallons

To Prepare.—Dissolve the soap in one gallon of boiling water. Remove from the fire and add two gallons of kerosene and agitate the mixture violently for fully ten minutes. As the kerosene and soap solutions combine, a smooth, creamy emulsion will result, and when properly mixed, will remain for weeks without separating. The emulsion is best prepared by using a small force pump, throwing a small stream and pumping the mixture back into itself for ten minutes. Soft water should be secured, but a little common lye may be used to "soften" water that is naturally too hard.

For convenient reference the proper amount of water used in diluting the stock solution to a certain strength is given below:

For 5 per cent emulsion dilute with 37 gallons of water.
For 10 per cent emulsion dilute with 17 gallons of water.
For 15 per cent emulsion dilute with 10 1-3 gallons of water.
For 20 per cent emulsion dilute with 7 gallons of water.

Tobacco Products (as a liquid spray).

Tobacco leaves or stems	2 pounds
Water	4 gallons

Boil for about 2 hours.

Tobacco water, made by the above formula, should be used at full strength. It is valuable for killing plant lice, and as a repellent against flea beetles, cucumber beetles, etc.

Tobacco Products (in dry form).

Tobacco dust is of some value as a repellent when applied liberally to the foliage of small garden plants.

Soap Solutions.

Whale oil soap, made from refuse fish oil, is a valuable contact poison for killing plant lice. The potash soaps are preferable to soda soaps. Common potash (washing or laundry) soap may be used with success at a strength of 1 pound in 3 or 4 gallons of water, and is just as effective against common garden plant lice as whale oil soap or dilute kerosene emulsion. This gives a little better result than tobacco water.

Pyrethrum.

Pyrethrum, also known as Buhach, Dalmation powder, and Persian Insect Powder, is poisonous to most insects, but harmless to higher animals. The powder gets into the breathing pores, acting by its suffocating effects, and it also contains an essential oil that kills by contact. As this oil evaporates rapidly when exposed to the air, pyrethrum must be kept in air-tight receptacles until used. Pyrethrum kept in open boxes or loose drawers is very nearly worthless.

Pyrethrum in dry form is used pure or diluted with flour, and will kill cabbage worms and most soft-bodied insects. It must be applied every two days while the insects are numerous.

Pyrethrum in solution is used by mixing 1 ounce in 2 gallons of water. In this form it will not injure the tenderest foliage.

Tobacco Fumigating Papers.

As stated on p. 41 tobacco fumigating papers have been carefully tested in Texas as a remedy for lice on cucumbers, cantaloupes, etc. The brands that have been well tested are Nico-fume Paper, To-bak-ine and Aphis Punk.

These papers are prepared so that they will burn rapidly and are generally lighted in tin cans under the fumigating frames, which are described on p. 41. Old tin cans with perforations near the bottom edge answer the purpose very well. The actual time required to kill the lice will vary, but may be easily determined by experience.

SPRAY PUMPS AND EQUIPMENT.

There are many forms of spray pumps on the market, some good, and some almost worthless for the purpose of spraying garden plants. Good, serviceable spray pumps fitted with suitable hose, extension rod, and nozzle, are quite necessary for the proper application of some materials recommended against garden insects. Readers who desire information on the subject of spray pumps and equipment should send for Bulletin 193 of the North Carolina Experiment Station, and should also write to a number of spray pump manufacturers for catalogues. Persons who have never used spray pumps will do well to investigate the merits of the different makes before making a purchase. The names of Spray Pump Concerns are listed in the Bulletin mentioned above.

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NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND

MECHANIC ARTS

WEST RALEIGH

HANDLING AND MARKETING OF MILK AND CREAM

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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HANDLING AND MARKETING OF MILK AND CREAM.

By JOHN MICHELS, Dairy Husbandman.

The investigations herein reported were undertaken with a view to aiding in the improvement and extension of the milk and cream industry in North Carolina. At present, the necessity for refrigeration and cleanliness is not sufficiently appreciated by most dairymen. Investigation shows that a large percentage of the milk retailed in the larger towns and cities is neither cooled nor aerated, a fact which causes much hardship and financial loss to the dairymen of the State.

Lack of thorough cooling necessitates two deliveries of milk per day, and, what is still worse, requires dairymen to milk their cows shortly after midnight and shortly after midday, a drudgery which casts a damper upon the whole milk business. Lack of cooling also means financial loss through souring of milk and leads to many dissatisfied customers. Suitable methods for cooling milk and cream, as well as plans designed by us for the construction of simple and cheap ice boxes and sterilizers for both large and small dairymen, are fully described and illustrated in these pages.

The cream industry of the State is still in its infancy and scarcely any attempt has been made at shipping this product, though this could be made profitable. Neglect of the development of this industry by our own people has led to its monopolization by dairymen of other States. We face the deplorable fact that several of the leading markets in this State are largely supplied by cream shipped from the State of New York.

Conspicuous among other things is the need of more and better dairy houses on dairy farms, and two ground plans of such houses have been prepared, which it is hoped will stimulate much needed improvement along this line.

Many points of general information, without which a milk and cream business can not be successfully conducted, have also been incorporated.

A COMPARISON OF CREAM SHIPPING CANS.

The object of making this comparison was to determine the relative efficiency of different types of cans in maintaining low temperatures. Four leading styles of cans were used: (1) an insulated metallic can; (2) an insulated wood jacketed can; (3) an ordinary ten-gallon milk can with felt jacket around it; and (4) an ordinary ten-

gallon can placed inside of a covered ice-cream shipping tub. An ordinary ten-gallon can was used as a control. (See Figs. 1, 2, 3, 4, 5.)

FIG. 1.—Insulated Metalic Can.

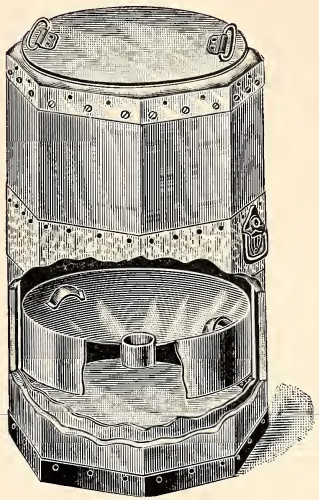

FIG. 2—Insulated Wood Jacketed Can.

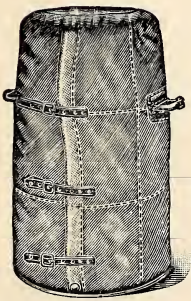

FIG. 3—Felt Jacketed Can.

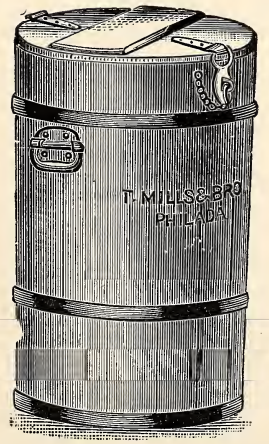

FIG. 4—Ice-cream Shipping Tub.

FIG. 5—Ordinary Milk Can.

In all the experiments, ten gallons of water was used in each can, and all cans were of ten gallons capacity, except the insulated metallic can, and the insulated wood jacketed can, which had a capacity each of twenty gallons. The initial temperature of the water in all cans was 45° F. in each experiment.

The relative rise of temperature at intervals up to twenty-four hours, as well as the room temperature to which the cans were exposed, are shown in the following table:

TABLE I.—Showing Relative Efficiency of Cans in Holding Temperature.[1]

Number of Experiment.	Number Hours after Cooling to 45° F.	Room Temperature.	Temperature.					
			Ordinary Milk Can.	Insulated Metallic Can.	Insulated Wood Jacketed Can.	Ordinary Milk Can Covered With Felt Jacket.	Ordinary Milk Can in Covered Wooden Tub.	Pounds Ice Used in Wooden Tub.
1	3	73	50	48	48	47	42	8
	6	73	52	49	49	48	40	
	9	70	56	52	52	50	42	
	24	71	60	57	57	56	52	
2	3	78	52	49	49	49	40	38[2]
	6	79	57	50	51	51	36	
	9	79	59	54	55	54	34	
	24	66	58	55	56	54	32	
3	3	79	50	48	48	48	38	8
	6	81	55	50	50	50	34	
	9	79	60	52	52	54	35	
	24	70	62	57	57	56	43	
4	3	74	50	48	48	48	48	None.
	6	74	54	50	51	50	50	
	9	72	56	51	52	51	52	
	24	70	60	56	56	56	56	
5	3	83	54	48	49	48	42	15
	6	84	61	52	53	52	40	
	9	78	64	54	55	54	41	
	24	77	67	59	60	59	52	
6	3	80	57	48	48	47	48	None.
	6	80	55	51	50	50	51	
	9	74	58	52	52	51	52	
	24	75	60	58	58	57	57	
7	3	83	54	48	48	48	42	20
	6	85	59	52	52	51	39	
	9	80	62	54	54	53	36	
	24	81	66	61	62	61	45	

[1] Ice used was broken into pieces about the size of two fists.
[2] Ice size of nut coal.

Table I shows that so far as maintaining temperature is concerned, there is practically no difference in the insulated metallic, insulated wood jacketed, and felt jacketed cans. It is clear, however, that where low temperatures are to be maintained for nine or more hours during warm weather, the covered wooden tub, which allows ice to be packed around the can, is the most satisfactory. The ice should be left coarse, and should be packed around the neck of the can. The amount needed will vary of course with the temperature of the atmosphere, and the length of time the cream is in transit. The wooden tub without ice has practically the same insulating effect as the felt jacket.

EFFECT OF TEMPERATURE ON THE KEEPING QUALITY OF MILK.

The bulk of milk produced in this State is sold to consumers without any cooling whatever; hence the prevailing practice of delivering the morning milk in time for breakfast, and the evening milk in time for supper. This practice, aside from necessitating two deliveries a day and resulting in much sour milk, requires the first milking of the day to be done shortly after midnight, and the second milking shortly after midday.

Few dairymen are willing to undertake dairying when the milking must be done at these hours. Certainly none could do so with any degree of pleasure. All this drudgery of night and day work can largely be obviated by thoroughly cooling the milk as soon as possible after milking, which will prolong its keeping quality. This is clearly shown in the following table, in which the night milk was cooled to 45° F., one hour after milking, and then placed in the refrigerator. The milk of the following morning was also cooled to 45° F., one hour after milking, after which it was placed at room temperature, simultaneously with the milk of the previous night, which had been held in the refrigerator. Both samples of milk were tested for acidity three times a day with the results recorded in Table II. With these and all other samples acid determinations were made by using one-tenth normal sodium hydroxide with phenolphthalein as indicator.

To those unacquainted with milk acid tests, it should be stated that milk is still perfectly sweet when it shows 0.25 per cent acid, and that the first signs of "turning" or souring are usually detected when the acidity reaches 0.30 per cent.

TABLE II.—Showing Acidity of Milk at Different Ages.

Number of Experiment.		Acidity of Milk—Percent.				
		5.00 p. m.	8.00 a. m.	12.00 noon.	5.00 p. m.	8.00 a. m.
1	Night milk	0.167	0.180	0.185	0.190	0.306
	Morning milk	----------	0.176	0.189	0.194	0.311
	Room temperature	43	74	82	81	82
2	Night milk	0.169	0.181	0.185	0.208	0.297
	Morning milk	----------	0.180	0.189	0.212	0.313
	Room temperature	45	74	83	78	70
3	Night milk	0.176	0.183	0.189	0.194	0.237
	Morning milk	----------	0.180	0.187	0.203	0.246
	Room temperature	45	70	75	77	64
4	Night milk	0.174	0.183	0.198	0.205	0.221
	Morning milk	----------	0.176	0.199	0.208	0.225
	Room temperature	43	60	72	70	59
5	Night milk	0.163	0.180	0.183	0.201	0.226
	Morning milk	----------	0.183	0.189	0.201	0.223
	Room temperature	45	70	72	71	60
6	Night milk	0.174	0.181	0.198	0.205	0.221
	Morning milk	----------	0.187	0.207	0.212	0.234
	Room temperature	43	69	70	75	68
7	Night milk	0.194	0.201	0.217	0.230	0.237
	Morning milk	----------	0.208	0.216	0.230	0.237
	Room temperature	43	71	79	73	73
8	Night milk	0.205	0.216	0.230	0.235	0.512
	Morning milk	----------	0.205	0.221	0.228	0.357
	Room temperature	45	73	78	78	72
9	Night milk	0.210	0.218	0.234	0.241	0.378
	Morning milk	----------	0.212	0.219	0.225	0.300
	Room temperature	44	72	76	77	72
10	Night milk	0.210	0.216	0.226	0.241	0.594
	Morning milk	----------	0.205	0.223	0.230	0.510
	Room temperature	45	72	84	78	82

TABLE II—Continued.

Number of Experiment.		Acidity of Milk—Per cent.				
		5.00 [1] p. m.	8.00 a. m.	12.00 noon.	5.00 p. m.	8.00 a. m.
11	Night milk	0.203	0.204	0.219	0.225	0.318
	Morning milk	----------	0.216	0.230	0.237	0.360
	Room temperature	45	75	80	80	76
12	Night milk	0.198	0.205	0.212	0.221	0.467
	Morning milk	----------	0.210	0.221	0.228	0.709
	Room temperature	45	76	75	77	74
13	Night milk	0.217	0.232	0.237	0.266	0.700
	Morning milk	----------	0.210	0.223	0.246	0.278
	Room temperature	46	82	92	82	75

[1] Temperature readings in this column were made in the refrigerator.

The results show that there is only a very slight development of acidity in milk which was kept at temperatures ranging between 43° and 45° F. They also show that night milk kept at these temperatures until the following morning (15 hours) and then placed at room temperature will keep sweet fully as long after being placed at this temperature as does the morning milk placed at the same room temperature immediately after cooling to 45° F. Table II further shows that night milk cooled to 45° F. and then kept at refrigerator temperature (43° F.) for 15 hours, will be sweet at the end of 24 hours, even when kept during the last nine hours at room temperature ranging from 82° to 92° F.

The results given in the following table were secured by cooling the morning milk to 45° F. one hour after milking, and then keeping it in the refrigerator for 24 hours. The night milk of the same day was cooled to 45° F., one hour after milking, and then placed in the refrigerator 15 hours, or until eight o'clock next morning, when it, together with the milk of the preceding morning, was placed at room temperature.

TABLE III.—Showing Acidity of Milk at Different Ages.

Number of Experiment.		Acidity of Milk—Percent.					
		8.00 a.m.	5.00 p.m.	8.00 a.m.	12.00 noon.	5.00 p m.	8.00 a.m.
1	Morning milk	0.194	0.198	0.201	0.216	0.219	0.241
	Night milk		0.170	0.205	0.219	0.230	0.507
	Room temperature			76	80	84	70
	Refrigerator temperature	45	40	42			
2	Morning milk	0.18	0.212	0.223	0.237	0.248	0.261
	Night milk		0.176	0.198	0.234	0.241	0.252
	Room temperature			86	84	76	84
	Refrigerator temperature	45	45	44			
3	Morning milk	0.187	0.201	0.212	0.219	0.230	0.518
	Night milk		0.187	0.198	0.201	0.221	0.313
	Room temperature			76	88	93	77
	Refrigerator temperature	45	40	41			
4	Morning milk	0.183	0.194	0.203	0.219	0.230	0.657
	Night milk		0.190	0.212	0.221	0.232	0.856
	Room temperature			79	85	95	78
	Refrigerator temperature	42	46	44			
5	Morning milk	0.187	0.212	0.217	0.226	0.234	0.248
	Night milk		0.187	0.216	0.223	0.241	0.252
	Room temperature			65	80	76	73
	Refrigerator temperature	45	42	41			
6	Morning milk	0.176	0.187	0.194	0.201	0.216	0.236
	Night milk		0.180	0.190	0.210	0.234	0.334
	Room temperature			73	86	89	76
	Refrigerator temperature	45	45	44			
7	Morning milk	0.198	0.205	0.214	0.221	0.228	0.252
	Night milk		0.194	0.216	0.223	0.228	0.248
	Room temperature			78	87	92	73
	Refrigerator temperature	44	43	44			
8	Morning milk	0.208	0.214	0.220	0.228	0.235	0.360
	Night milk		0.210	0.212	0.226	0.237	0.370
	Room temperature			73	84	86	80
	Refrigerator temperature	44	46	46			

TABLE III.—Continued.

Number of Experiment.		Acidity of Milk—Percent.					
		8.00 a. m.	5.00 p. m.	8.00 a. m.	12.00 noon.	5.00 p. m.	8.00 a. m.
9	Morning milk	0.208	0.219	0.223	0.235	0.235	0.306
	Night milk		0.214	0.216	0.219	0.221	0.300
	Room temperature			80	89	89	71
	Refrigerator temperature	46	44	43			
10	Morning milk	0.210	0.216	0.223	0.226	0.237	0.252
	Night milk		0.194	0.199	0.214	0.230	0.237
	Room temperature			71	70	73	73
	Refrigerator temperature	43	43	41			

This table, like the preceding, shows that there is but slight acid development in milk kept at refrigerator temperatures ranging from 42° to 45° F. The morning milk kept at these temperatures showed an average increase of acidity of only 0.05 per cent during twenty-four hours. These results also show that morning milk, after being kept at 42° to 45° F. for twenty-four hours, and then placed at high room temperatures is still perfectly sweet at the end of thirty-three hours.

MILK DELIVERIES.

The facts brought out in connection with our cooling experiments clearly show that the time of the delivery of milk may be made entirely independent of the time of milking. When milk is cooled to 45° F. and kept at this temperature, the night milk may be delivered the following morning, either in time for breakfast or after. The morning milk may be kept in the refrigerator till after dinner and delivered before supper. Of course the milk will be fresher and sweeter for the consumer when the night milk is delivered before breakfast, so that the morning milk need not be kept over night by the consumer.

Upon our advice, this latter plan of delivery has been adopted by a local dairyman, who, like the vast majority, had been in the habit of milking his cows shortly after midnight and shortly after midday and delivering his milk, without cooling, immediately after milking. The effect of the change has been a marked improvement in the quality of his milk, as is evidenced both by a marked increased demand for it as well as by a very material reduction of its bacterial content. From the middle of March to the middle of May, 1907, under the old system, the number of bacteria contained in his milk averaged 634,400 per cubic centimeter, while under the new system

for the corresponding period of 1908, the number of bacteria averaged only 236,000 per cubic centimeter, a reduction of 63 per cent. This reduction in bacterial content, furthermore, was accomplished in spite of the fact that the cooled milk reached the market from six to twelve hours older than did the uncooled milk delivered under the old system. In addition, this dairyman and his milkers found the work under the new system much more agreeable, because it permitted the milking to be done at hours which suited their convenience and comfort.

With thorough cooling, it is possible to deliver both night and morning milk at the same time, preferably before dinner. Milk so delivered will be sweet the following morning, especially when kept cool in transit and in the home of the consumer.

Whatever plan of delivery is adopted, it is certain that milk thoroughly cooled and kept cool fifteen hours before delivery, will give consumers better satisfaction than milk delivered immediately after milking without cooling. Not only will the milk be of better quality but the milkman may milk his cows at his convenience, say at 5 o'clock in the morning and 4 o'clock in the afternoon, or just as he would if he were making butter.

ACIDITY OF FRESH MILK.

In Tables II and III, the first acid determination reported for both the night and morning milk was made one hour after milking. The percentage thus found in fresh milk averaged nearly 0.2 per cent, or practically double that ordinarily reported by dairy chemists.

The ration fed, while these acid determinations were being made, consisted of corn stover and corn silage as roughage, and four parts cotton-seed meal, two parts dried brewers' grains, and two parts corn meal as the concentrates. A few cows, however, received no silage, but the acidity of their milk was practically the same as that secured from silage-fed cows. The high acid-content of all these samples can not therefore be ascribed to the feeding of silage.

Some of the milk was boiled slightly to drive off any carbon dioxide which it might contain, with the result that a slightly reduced percentage of acid was found. Further studies are being made to ascertain, if possible, the cause for the presence of the unusually high percentage of acid found in the fresh milk used in these experiments.

A CHEAP AND EFFECTIVE ICE BOX.

Cold storage of some kind is indispensable to a well equipped dairy. Many, however, lack this essential, and probably largely owing to the high cost of commercial refrigerators. The construction of the ice box detailed below is the result of an attempt to give dairymen a serviceable cold storage at as low a cost as possible.

The construction of this box, shown in Fig. 6, consists essentially of two boxes separated by 1-inch strips placed at intervals of about one foot. Double thickness of building paper is placed on both sides of the strips and tacked to the boxes. A 1-inch strip, two inches wide, covers the upper space between the 1-inch strips, thus making a dead-air space between the two boxes. The construction of the cover is the same as that of the bottom, with the exception that there is a flange at the front and sides of the cover.

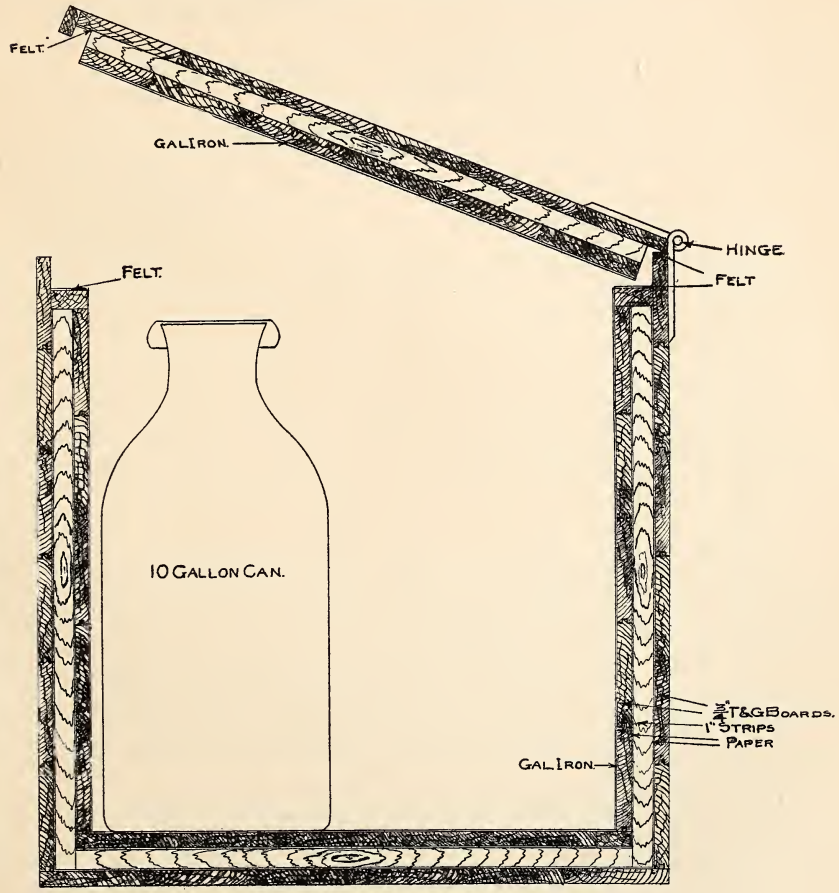

Fig. 6—Cross-section through Ice Box.

The sides, bottom and cover of the refrigerator are built of $\frac{3}{4}$-inch tongued and grooved lumber, five and a half inches wide. The ends are constructed of $1\frac{1}{8}$-inch tongued and grooved flooring three and a half inches wide. The inside of the ice box is lined with galvanized iron. To insure tightness, a layer of felt is tacked around

the box and cover where the two meet. The four vertical edges of the refrigerator are tightened and strengthened by tacking over each a double layer of paper, which is covered with two 6-inch boards.

A heavy weight attached to a ½-inch rope, running over a pulley fastened to the ceiling, raises the cover and holds it open when desired. A short piece of rope with a hook attached is used to counterbalance the weight by hooking to the side of the box, thus allowing the full weight of the cover to rest on the box.

A short piece of ½-inch gas pipe is inserted through the bottom of the box to provide drainage, the outlet of this pipe being immersed in a cup of water to prevent entrance of air into the box.

The entire construction of the ice box is so simple that any one with a little knowledge of carpentry can readily build it.

The inside dimensions are: Length, 7 1-3 feet; width, 2¼ feet; depth, 2 1-3 feet.

An itemized statement of the cost of it is as follows:

200 ft. ¾″ x 5½″—16′ tongued and grooved lumber	$4.00
54 ft. 1⅛″ x 3½″—16′ tongued and grooved lumber	2.16
168 ft. 1″ x 1″—12′ strips	1.26
4 hinges	.60
½ yard felt	.63
15 ft. ½-inch rope	.30
2 strong hooks	.10
1 2-inch iron pulley	.50
Carpentry work, 3 days	6.00
Complete lining with galvanized iron	11.25
500 sq. ft. building paper	.60
Total cost	$27.40

Commercial refrigerators of equal capacity and no greater efficiency will cost from $60.00 to $100.00, or about three times as much as the refrigerator above described.

A test of this ice box for six days with an average of 200 pounds of ice in the box showed that an average temperature of 39° F. was maintained within it, with an average daily consumption of 40½ pounds of ice, while the temperature of the room in which the ice box was kept averaged 74° F.

When twenty-two gallons of milk, which had been cooled to 45° F., were stored in the box eight hours daily with the other conditions as above, the average daily ice consumption for six days was 49 pounds, and the average temperature of the box 40° F.

A CHEAP AND EFFICIENT STERILIZER.

All vessels and appliances used in the handling of milk, cream and butter should be rendered sterile after washing, either by placing them in boiling water for about five minutes or by steaming them for an equal length of time.

Small dairies without boilers should sterilize with hot water, but the larger dairies will find it advantageous to use a steam boiler and sterilized with steam. To perform this operation efficiently, it requires a closed steam chest large enough to hold everything that is

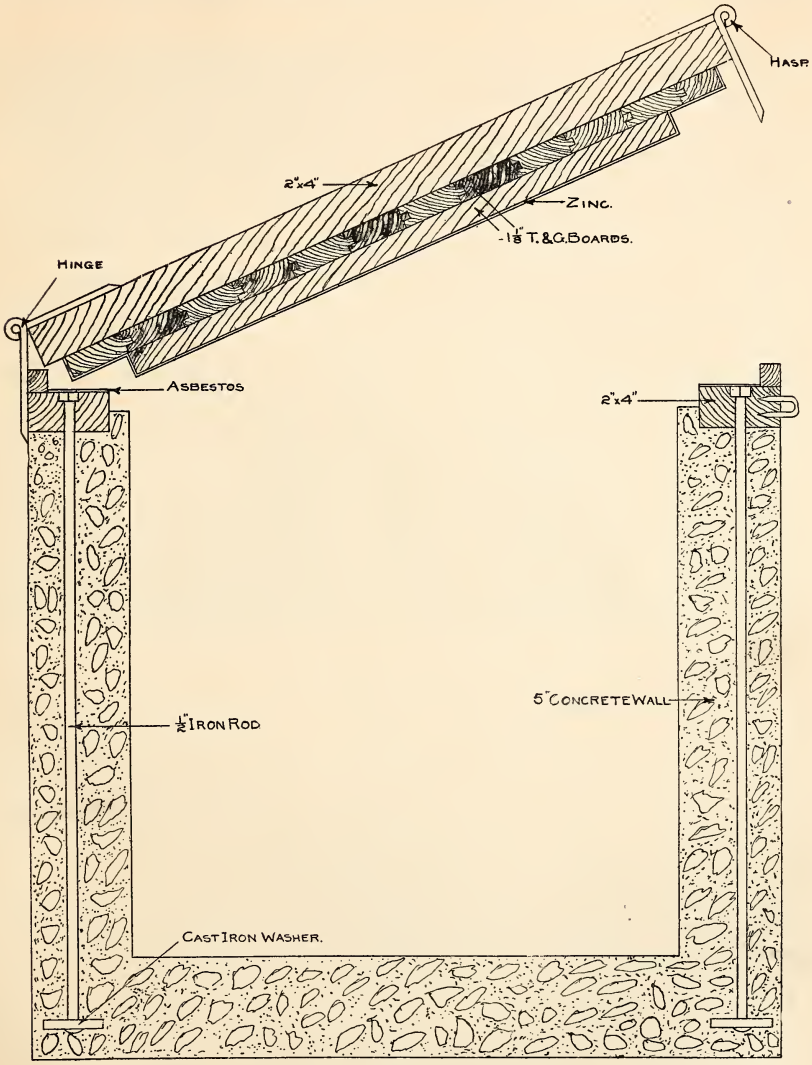

Fig. 7—Cross-section of Sterilizer.

to be sterilized. Sterilizers of this type are usually constructed of concrete, or brick and concrete, and are provided with a heavy iron door, this being large enough to admit a truck bearing the pails, cans, bottles, etc. Still other sterilizers of this type are constructed of

galvanized iron or boiler plate, and all permit of sterilizing under more or less pressure.

The principal drawback to these various steam sterilizers is the high cost, which renders their use by the smaller dairymen almost prohibitive. After considerable experimentation and study, the writer has succeeded in constructing an efficient sterilizer which will cost only about one-third as much as the cheapest sterilizer of the type just mentioned. The construction of this new sterilizer, whose inside dimensions are: 7 feet long by 2¼ feet deep, by 2¼ feet wide, is very simple. (See Fig. 7.)

Essentially, it is a rectangular concrete tank with a wooden cover, which is lined with zinc. The sides and bottom are five inches thick and are built of concrete, which is made up of one part cement, two parts sand, and two parts coarse gravel. A thin coat, consisting of one part cement and two parts sand, is used as an inside finish. A piece of 2 x 4 studding is placed around the top of the tank and is secured by six ½-inch iron rods, two feet long, embedded in the concrete walls, one being placed at each corner, and one on either side midway between the corners. This arrangement not only strengthens the tank, but also makes the cover fit tighter.

The cover consists of two thicknesses of 1 1-8-inch tongue and grooved flooring 3½ inches wide. The upper boards run lengthwise and the lower crosswise of the tank. The lower boards fit into a shoulder projecting from the base of the 2 x 4 studding. The entire inside portion of the cover is covered with zinc. To insure additional tightness of the cover, a layer of asbestos is placed on top of the 2 x 4s. A safety valve, set at ten pounds pressure, is inserted through the top of the cover at the most convenient place. An outlet for condensed steam is provided at the bottom.

The cover is raised and lowered in the same manner as that of the ice box described on page 15. The cover is strengthened by running three pieces of 2 x 4 studding crosswise of the tank, one at the middle and one at either end. The hinges, by which the cover is fastened, are attached to these 2 x 4 pieces, as shown in Fig. 7.

The following is an itemized statement of the approximate cost of the material of this sterilizer when the inside dimensions are: Length, 7 1-3 feet; width, 2¼ feet; depth, 2 1-3 feet:

2	bbls. of Portland cement	$5.20
20	ft. of 2 x 4 studding	.30
110	ft. of 1⅛ tongue and grooved flooring, 3½ wide	4.40
4	hinges	.40
5	lbs. nails	.20
6	½-inch iron rods 2½ feet long	1.20
3	hasps	.30
20	sq. ft. zinc	1.75
	Ball and lever safety-valve	1.00
3	pounds sheet asbestos	.30
	Total	$15.05

EFFICIENT MILK AND CREAM COOLER.

After a careful test of different cooling devices, it has been found that for dairies having twenty or more cows the cooling arrangement shown in Fig. 8 is the best thus far tried. This flat, corrugated

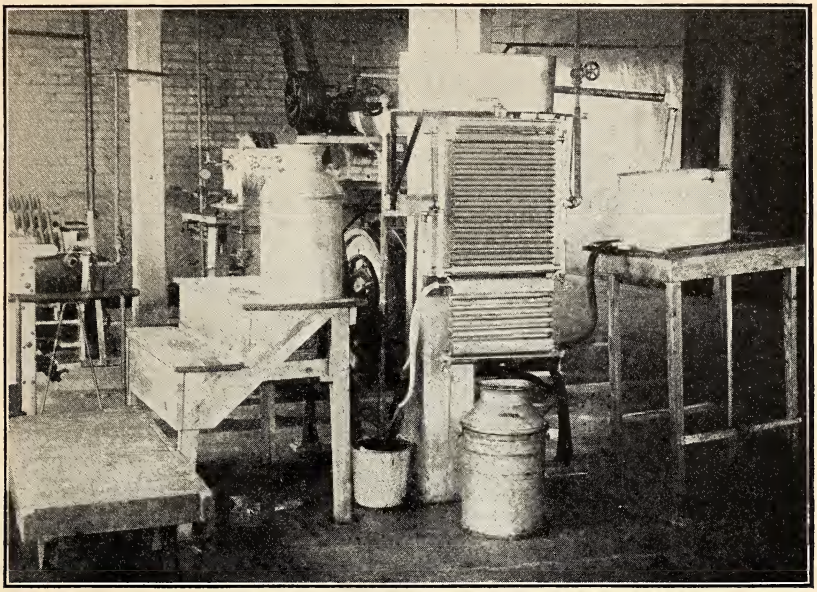

Fig. 8—Milk and Cream Cooler.

cooler consists of two parts: an upper section, which is used for cooling milk or cream with uniced water, and a lower section, through which ice water is circulated. By means of the pump at the left, the ice water is pumped back in the tin can at the right, which contains the ice. The well water is admitted to the upper section of the cooler by opening the valve shown at the upper right-hand corner of the cooler. On a farm, a barrel or tank elevated to the height of this valve could be used as a water storage from which water may be drawn into the upper section of the cooler. The water in both sections enters at the bottom between the two corrugated surfaces and discharges at the top, the milk flowing over the outside.

As might be expected, by forcing the ice water from the cooler back into the ice water storage, a considerable saving is effected, not only of ice and water, but of time as well. Proof of these advantages is brought out by the results recorded in the following table, which shows the work of the cooler with and without the ice water pump. When no pump was used, ordinary well water was sprayed

over finely crushed ice in the can shown at the right, and the discharge was allowed to run into the drain.

All the milk was cooled to 45° F., and the amount of milk cooled in each experiment was eighty-four gallons, one-half of which was cooled with a pump and the other half without:

TABLE IV.—Showing Work of Cooler With and Without the Pump.

Number of Experiment.		Amount Ice Used—Pounds.	Time in Cooling—Minutes.	Temperature of Milk Before Cooling—Degrees F.	Temperature of Well Water—Degrees F.
No. 1	With pump	37	45	85	73
	Without pump	89	92	88	73
No. 2	With pump	35	40	85	66
	Without pump	94	82	84	66
No. 3	With pump	32	35	82	64
	Without pump	85	93	85	64
No. 4	With pump	38	45	88	72
	Without pump	95	85	85	72
No. 5	With pump	34	43	85	70
	Without pump	83	88	88	70
Average	With pump	35	41	85	69
	Without pump	89	88	86	69

For smaller dairies, a cheap cooler like that shown in Fig. 9 may be used to advantage. The water enters the bottom of the cooler and

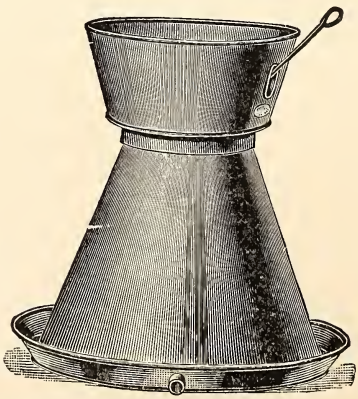

Fig. 9—Milk and Cream Cooler.

discharges at the top, the milk flowing in a thin sheet over the outside. Ice may be placed inside of the cooler.

GROUND PLAN FOR DAIRY HOUSES.

Two satisfactory ground plans for dairy houses are shown in Figs. 10 and 11.

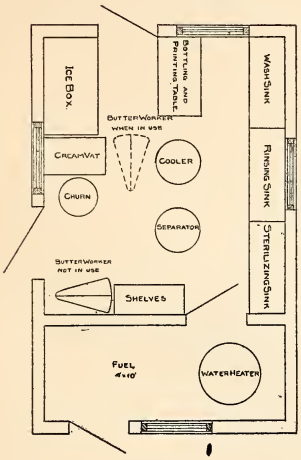

Fig. 10—Ground Plan for Dairy House for 10 to 20 Cows.

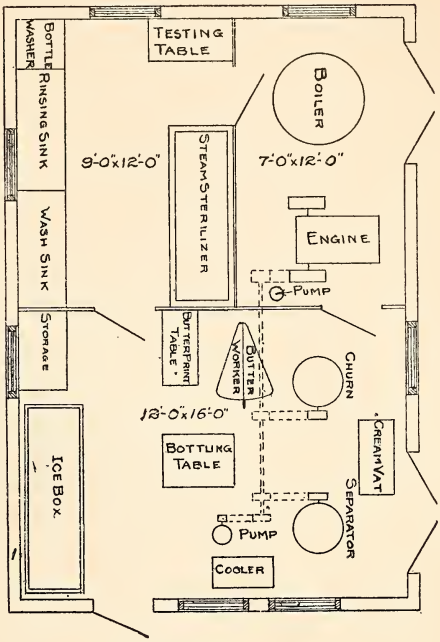

Fig. 11—Ground Plan for Dairy House for 20 to 50 Cows.

(Interchange position of cooler and bottling table in Fig, 11.)

The dimensions of the smaller dairy house are 10′ x 16′, and those of the larger 16′ x 24′.

GENERAL INFORMATION.

Many cities in North Carolina are suffering from a shortage of milk and cream, in spite of the remunerative prices which are offered for these products. This, no doubt, is largely due to the fact that dairymen remotely situated from cities, believe that distance must necessarily deprive them of city markets. It is certain at any rate that scarcely any effort is being made by these dairymen to cater to city trade. Enquiry shows that shipment of cream and milk by rail has scarcely been attempted in this State. Yet that this can be successfully done is amply proven by our own experience and by the fact that a large portion of the cream used in the State is sent in from other States.

To make milk and cream shipment a success, however, it is necessary to understand the correct handling of the milk from the time

it leaves the cow until it reaches the city dealer. The brief discussion which follows is intended to supply this information.

SANITARY MILK PRODUCTION.

The first and most important essential in building up a successful cream and milk business is cleanliness. Milk produced and handled under filthy conditions is dangerous to the health of adults and is one of the chief causes of the high mortality among infants. A large proportion of the consumers in cities is conscious of these dangers, and will pay almost any price for milk and cream that are known to be clean and wholesome. The conditions necessary for the production of a high class of milk are discussed in the following paragraphs:

Healthy Cows.—The health of the cow is of prime importance in the production of sanitary milk. All milk from cows affected with disease of any kind should be discarded. Aside from the general unfitness of such milk, there is danger of disease producing organisms getting into the milk. It has been found, for example, that cows whose udders are affected with tuberculosis, yield milk containing the germs of this disease. Even where the udder is not affected, there is great danger of infecting the milk with tubercle germs, because these germs are frequently found in the dung of tuberculous cows. The prevalence of this disease among cows makes it imperative to determine definitely whether or not cows are affected with it.

Clean Cows.—The source of most of the dirt commonly found in milk is the cow; hence the importance of keeping her thoroughly

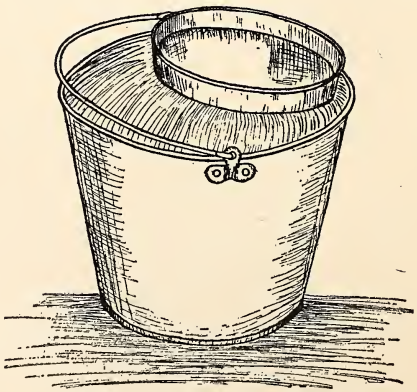

Fig. 12—Covered Milk Pail.

clean. This requires clean dry barns and barnyards, daily carding of the cows, and washing of the udder before milking. A covered pail like that shown in Fig. 12 reduces contamination to a great extent.

Sterile Milk Vessels.—All vessels used in the handling of milk and cream should be made of good tin, with as few seams as possible. Wherever seams occur, they should be flushed with solder. Unflushed seams are difficult to clean and afford good breeding places for bacteria. It is very important to clean and sterilize all milk vessels as soon as possible after use. This is satisfactorily accomplished as follows:

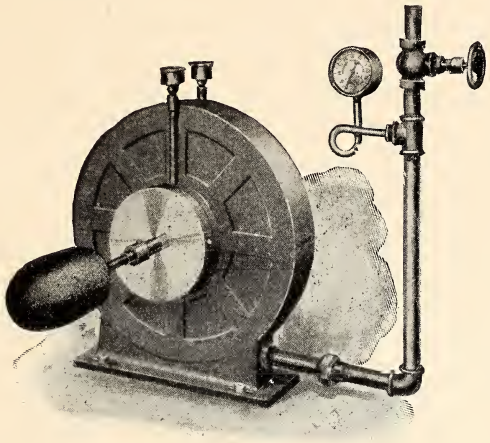

Fig. 13—Bottle Washer.

First, rinse with warm or cold water, which should be followed by scrubbing with moderately hot water containing some alkali, like sal soda. The washing should be done with brushes rather than cloths, because the bristles enter into crevices which the cloth could not possibly reach. Next scald thoroughly with steam or hot water after rinsing in clean water. After scalding, the utensils should be inverted on shelves without wiping and allowed to remain until ready for use. If possible, turn the inside of the vessel to the direct rays of the sun in a place where there is no dust. The best place in which to leave the vessels is a covered sterilizer.

Clean Milkers.—No diseased or convalescent person should come in contact with the cows. At milking time, clean milking suits should take the place of those worn in the fields, and the milkers should wash their hands thoroughly just before milking. The filthy practice of milking with wet hands can not be too strongly condemned, since it is just as easy, if not more so, to milk with dry hands. Where the milker wets his hands with milk, some of it is bound to drop into the pail, carrying with it thousands or even millions of bacteria.

Clean, Wholesome Feed and Water.—Highly fermented and aromatic feeds like sour brewers' or distillery grains and wild onions when eaten by the cows, are certain to produce bad flavored milk. The same may be said of impure or stagnant water.

Dust Free Air.—Great precaution should be taken not to raise any dust in the stable about milking time, for some of this will be certain to find its way into the milk. Cows should therefore never be bedded or given dusty feed just before or during milking.

Straining Milk.—Milk should be drawn so clean as to make it almost unnecessary to strain it. This operation is frequently done under the illusion that so long as it removes all visible dirt the milk has been entirely purified. The real harm, however, that comes from hairs and dust particles dropping into the milk is not so much in the hairs and dust particles themselves as in the millions of bacteria which they carry with them. These bacteria are so small that no method of straining will remove them. Straining can not even remove all of the dirt, because some of it will go in solution.

A good strainer consists of two thicknesses of cheese cloth with a layer of absorbent cotton between. The strainer is to be placed on the can or vat into which the milk is to be strained and not on the milk pail.

Flies.—Flies not only constitute a prolific but also a dangerous source of milk contamination. These pests visit places of the worst description and their presence in a dairy suggests a disregard for cleanliness. Of 414 flies examined by the Bacteriologist of the Connecticut Station, the average number of bacteria carried per fly was *one and a quarter millions.*

NECESSITY FOR THOROUGH COOLING.

Next to cleanliness, a low temperature is of the greatest importance in marketing milk and cream. The temperature should be reduced to 45° F. or below as soon as possible after milking. This requires special coolers like those shown in Figs. 8 and 9. Cooling not only materially prolongs the keeping quality of milk, but also improves its flavor. Milk, no matter how clean, will have a more or less stifled odor if bottled without cooling.

If the milk or cream is to be held any length of time after cooling, it should be put into an ice box similar to the one described on page 13.

RELATIVE MARKET VALUE OF MILK, CREAM AND BUTTER.

Whether it pays best to sell milk, cream or butter depends largely upon the market prices for these products. In North Carolina these prices will average about as follows: butter, 25 cents per pound;

milk, 8 cents per quart; and cream, testing 20 per cent butter fat, $1.00 per gallon. Accepting these as average prices, let us determine the relative returns from one hundred pounds of milk containing 4 per cent butter fat, when (1) retailed by the quart; (2) when sold as cream; and (3) when made into butter.

One hundred pounds of 4 per cent milk is equal to 46.5 quarts (a quart of milk weighs 2.15 pounds), which at 8 cents per quart is worth $3.72.

One hundred pounds of 4 per cent milk will make 2.5 gallons of cream testing 20 per cent fat, as determined by the following formula:

$$X = \frac{(A \times B)}{C}, \text{ in which}$$

X = Number pounds of cream
A = Number pounds of milk
B = Test of milk
C = Test of cream
Substituting we get,

$$X = \frac{(100 \times 4)}{20} = 20, \text{ the number of pounds of cream.}$$

At 8 pounds to the gallon the 20 pounds of cream will be equal to 2.5 gallons which, at $1.00 per gallon, will bring $2.50. Allowing 1 cent per pound for the skim milk, we have 80 cents as the selling price of skim milk, which, when added to the $2.50, gives a total value of $3.30 for each hundred pounds of milk.

One hundred pounds of 4 per cent milk will yield 4 2-3 pounds of butter, because where up-to-date methods of creaming and churning are followed every pound of butterfat will make 1 1-6 pounds of butter. Four and two-third pounds of butter at 25 cents per pound are worth $1.17. Valuing buttermilk at the same price as skim milk (1 cent per pound), 95 cents should be added to the $1.17 as the value of the skim milk and buttermilk, which makes a total value of $2.12.

The preceding calculation shows that at the prices given, 100 pounds of 4 per cent milk is worth $3.72 when retailed by the quart; $3.30 when sold as cream in bulk; and $2.20 when made into butter. Since selling the cream in bulk requires much less labor than retailing milk by the quart, and since cream also sours less quickly than milk, there is no question whatever that it is more profitable to sell cream than milk. It is also evident that it pays better to retail milk, where this is possible, than to make butter.

STANDARDIZING CREAM AND MILK.

This is a process by which milk and cream are brought to a definite percentage of fat. For example, one customer may want cream testing 30 per cent fat, another may prefer 20 per cent and still another may want 40 per cent, and so on. While the cream

separator may be regulated to give cream of any desired richness, there will necessarily be some variation in the percentage of fat from day to day, so there must be devised some way of getting cream to test the same every day. This is best accomplished by producing cream somewhat above the richness desired and then reducing the same to the required richness by the addition of skim milk. The amount of skim milk to be added is determined from the following formula:

$$X = \frac{(A \times B)}{C} - A, \text{ in which}$$

X = Number pounds of skim milk to be added
A = Number pounds of original cream
B = Test of original cream
C = Test desired.

Problem.—How many pounds of skim milk must be added to 70 pounds of cream testing 44 per cent to reduce the test to 20 per cent? Applying the formula we get—

$$X = \frac{(70 \times 44)}{20} - 70 = 84 \text{ pounds.}$$

This formula may also be used in standardizing milk.

THE CREAM SEPARATOR.

Dairies having four or more cows should cream their milk with a centrifugal machine, a hand separator. The saving of butter fat by the use of this method will soon pay for the cost of the separator. Moreover, this method has additional advantages over the common gravity or shallow pan method of creaming, in that it provides fresh, sweet cream of any desired richness as well as furnishing sweet skim milk for feeding purposes. The man who sells cream should provide himself with a centrifugal cream separator.

That the owner of four good cows can afford to invest $50.00 in a small cream separator that would answer for this number of cows, is shown by the following: Four good cows will yield not less than 24,000 pounds of milk a year. By the common shallow pan method of creaming, the loss of butter fat will average 0.7 pound for every 100 pounds of milk. With the centrifugal separator the loss of fat will not average over 0.05 pound, hence there will be effected a saving of 0.65 pound of butter fat in each 100 pounds of milk by the use of the separator. At this rate, the total saving of butter fat annually on the 24,000 pounds of milk will be 156 pounds. Since each pound of butter fat will yield approximately 1 1-6 pounds of butter, 183 pounds of butter will be saved by the process, which taken at 25 cents per pound amounts to a difference of $45.75. This saving in butter fat alone will almost pay for the separator in one year.

Bulletin 199 June, 1908

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND

MECHANIC ARTS

WEST RALEIGH

FEEDING EXPERIMENTS WITH COWS AND CALVES

I. COMPARISON OF COTTON-SEED HULLS AND SHREDDED CORN STOVER FOR MILK PRODUCTION

II. CORN MEAL VERSUS A MIXTURE OF CORN MEAL AND DRIED BREWERS' GRAINS AS A SUPPLEMENT TO COTTON-SEED MEAL FOR MILK PRODUCTION

III. ROLLED OATS AS A PARTIAL SUBSTITUTE FOR MILK IN CALF FEEDING

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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CONCLUSIONS.

The cottonseed hulls and shredded corn stover fed in this experiment were of equal value as milk and butterfat producers. It should be stated, however, that the hulls were of good average quality, while the stover was below average, especially in palatability.

It is a wasteful practice for farmers to purchase cottonseed hulls at $8.00 per ton when shredded corn stover of inferior quality can be fed with equally satisfactory results.

Rolled oats constitute an excellent substitute for milk in calf feeding. They are highly relished by young calves and materially reduce the cost of feeding where no skimmed milk, or an insufficient amount, is available for the purpose.

The results indicate that 4.4 cents worth of rolled oats (the cost of one pound) when fed in moderate quantity, is nearly equal to one gallon of whole milk.

With corn stover as the exclusive roughage, corn meal and dried brewers' grains have practically equal feeding value when supplemented by a grain ration consisting of one-half cottonseed meal and one-quarter corn meal.

With most cows, the continuous feeding of corn stover as the exclusive roughage results in too rapid shrinkage in milk flow for best returns.

The results of these experiments incline us to recommend to dairymen who are feeding much corn stover, a grain ration consisting approximately of one-half cottonseed meal, one-quarter corn meal, and one-quarter dried brewers' grains, or wheat bran or some other similar light, fluffy, concentrate, depending upon the relative market price of these feeds.

COMPARISON OF COTTONSEED HULLS AND SHREDDED CORN STOVER FOR MILK PRODUCTION.

By JOHN MICHELS, Dairy Husbandman.

Statistics recently gathered by the writer show that a large number of dairymen in North Carolina feed cotton-seed hulls, either alone or in combination with other coarse feeds, as roughage for dairy cows. Indeed it was found that hulls were fed more largely than any other kind of roughage. More than one and one-half times as much hulls as corn stover are being fed.

Why farmers will continue to pay high prices for hulls rather than feed stover can be explained only on the supposition that they do not fully realize the feeding value of stover. This belief is strengthened by the fact that many of them do not even attempt to harvest corn stalks, but allow them to go to waste in their fields.

OBJECT AND PLAN OF EXPERIMENT.

In view of the facts presented above, it was thought desirable to demonstrate the feeding value of corn stover by feeding it in comparison with cotton-seed hulls, one of the most commonly fed roughages.

For this experiment seven grade cows, from two to three months in lactation, were fed during three periods. The roughage consisted of shredded corn stover in the first and third periods, and of cotton-seed hulls in the second period. Closing the test with the same roughage used at the beginning tends to balance up any changes in milk and butter-fat yield due to advanced stage of lactation and the unfavorable effects of continued feeding on dry roughage. The grain ration was the same throughout the test. It consisted of a mixture of 4 pounds of cotton-seed meal, 2 pounds of dried brewers' grains, and 1 pound of linseed meal. All cows received 8 pounds of the grain mixture per day except Nos. 6 and 7, which received 10 pounds. The amount of roughage which the cows received was the same throughout the test, being 14 pounds per individual, with the exception of cows Nos. 1 and 4, each of which received 16 pounds per day.

Each period lasted twenty-two days exclusive of thirteen days preliminary feeding for Periods II and III and twenty days preliminary feeding for Period I. The longer preliminary feeding for Period I was thought desirable because the cows did not take very kindly to an all-dry feed after having been on a ration of equal

parts of stover and silage for more than two months prior to the experiment.

The milk from each cow was weighed daily, and weekly determinations were made on composite samples of the milk by the Babcock test. All cows were weighed once a week.

The hulls were mixed with the concentrates before feeding. The stover, on the other hand, was always fed after the concentrates.

The corn from which the stover was made was thoroughly matured before cutting and allowed to stand in small shocks in the field from six to eight weeks, during which time it had received several drenching rains. There was practically no green color left in the stover at the time of shredding; neither were there any corn grains or nubbins found in it. On the whole, the stover was of a rather inferior quality. The following analyses, supplied by the Chemical Division, gives an idea of the grade of the different feeds used in this and the following experiments:

TABLE I.—Percentage Composition of Feeds.

Feed.	Moisture.	Protein.	Fat.	Nitrogen—Free Extract.	Crude Fiber.	Ash.
Cottonseed Hulls	10.76	5.72	1.04	29.07	51.17	2.24
Cottonseed Meal	6.87	38.93	10.53	28.08	8.79	6.80
Linseed Meal	8.03	34.87	8.81	34.18	8.83	5.28
Dried Brewers Grain	7.92	22.56	5.76	42.14	18.33	3.29
Corn Stover	7.83	4 04	1.31	47.29	35.18	4.35

MILK AND BUTTERFAT PRODUCTION.

The milk and butterfat yielded by each cow during the test are shown in the following table:

TABLE II.—Showing Milk and Butterfat Yields, and Live Weight.

No. Cow.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight of Cows—Pounds
1	I. Stover	335.2	5.0	16.76	660
	II. Hulls	332.8	5.4	17.97	656
	III. Stover	316.7	5.4	17.10	639
2	I. Stover	400.2	4.1	16.40	687
	II. Hulls	342.	4.2	14.36	687
	III. Stover	316.6	4.2	13.30	672
3	I. Stover	405.4	4.4	17.83	587
	II. Hulls	353.4	4.9	17.31	571
	III. Stover	340.3	4.8	16.33	569

TABLE II.—Continued.

No. Cows.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight of Cows—Pounds.
4	I. Stover	434.4	4.5	19.55	824
	II. Hulls	375.	4.7	17.62	794
	III. Stover	331.	4.6	15.23	767
5	I. Stover	468.7	4.5	21.19	805
	II. Hulls	409.8	4.5	18.44	785
	III. Stover	363.4	4.5	15.35	806
6	I. Stover	359.7	4.4	15.82	784
	II. Hulls	278.5	4.8	13.36	769
	III. Stover	262.4	4.7	12.33	778
7	I. Stover	335.6	5.2	17.45	683
	II. Hulls	322.9	5.4	17.43	657
	III. Stover	284.3	5.7	16.77	658

From the results contained in Table II it will be seen that all cows fell off in milk yield during the Hull period and again during the Stover period following, the amount varying with different individuals. It is noteworthy also that in the case of cows Nos. 3, 4 and 6 the percentage of fat present in the milk was a trifle higher in the Hull period than in the Stover period. This may possibly be due to the rather large shrinkage in milk in these instances.

The total yield of milk and butter-fat for each period is shown in the table below:

TABLE III.—Showing Total Yield of Milk and Butterfat and Total Live Weight.

Periods.	Milk—Pounds.	Butterfat—Pounds.	Live Weight—Pounds.
I. Stover	2739.2	125.0	5030
II. Hulls	2414.4	116.5	4919
III. Stover	2224.7	107.4	4889

Averaging the results of the two stover periods in Table III we find that the cows yielded 2482.0 pounds of milk during the Stover period against 2414.4 pounds for the Hull period. Similarly the cows during the Stover period yielded 116.2 pounds of butter-fat as against 116.5 pounds for the average of the Hull periods, showing in this experiment that cotton-seed hulls and corn stover had practically equal value as milk and butter-fat producers.

Table II shows that the average weight of the individual cows was less during the Hull period than during the first Stover period, excepting cow No. 2, whose weight remained the same. Going from the Hull period to the last Stover period we find that four of the cows lost in weight, two gained and one remained practically unchanged.

Taking the weights of the cows collectively, we find that they averaged 111 pounds less in the Hull period than in the first Stover period, and 30 pounds less in the last Stover period than in the Hull period.

On the whole it may be concluded that the cotton-seed hulls and corn stover used in the experiment had about equal value in maintaining the live weight of the cows.

HULLS AND STOVER REFUSED.

The roughage refused at each feed was weighed and recorded separately for each cow. It was found that the amount of stover refused averaged from 3 to 4 pounds per cow, with the exception of cow No. 3 (the lightest in weight), which refused from 4 1-2 to 5 pounds daily.

At the beginning of the Hull period an attempt was made to feed the hulls and concentrates separately. This proved a failure, since most of the cows refused the hulls, and only a few ate as much as one-half the allowance supplied them. After the second day, therefore, the hulls were always mixed with the concentrates before feeding. Even when fed in this manner some of the cows showed a strong dislike for the hulls the first week, after which practically the entire amount supplied was consumed except in the case of cows Nos. 6 and 7, each of which would occasionally refuse from 1 to 3 pounds per day.

CORN STOVER.

For years corn stover has formed an important part of the roughage fed to cattle in the live stock sections of this country. This feed is especially suited for feeding in cotton growing sections where the majority of farmers have insufficient stock to warrant the erection of silos; and even where farmers have silos there will always be more or less stover to feed because of the large amount of corn which is planted solely for the grain it yields, leaving the stover as a by-product. But because it is a by-product it is not necessarily to be inferred that it is worthless; yet so it is undoubtedly considered by many, as evidenced from the thousands of acres of cornstalks which are allowed to go to waste in the fields every fall.

An important consideration in making stover is to have it palatable. The corn should therefore be cut as soon as sufficiently ma-

tured, and be placed in shocks containing from one hundred to two hundred stalks. During fair weather the corn may be husked, as a rule, from two to three weeks after it is cut. When husked by a machine the stover is shredded at the same time, and placed under shelter. When husked by hand the stover should be sheltered with the same care and promptness. Long exposure of the stover in the fields greatly diminishes its nutritive qualities as well as its palatability. The damage to stover is especially great when drenched by heavy rains.

It is usually best to cut the stover in small pieces, say from one to three inches long, before feeding. Less is wasted by cattle in this way than when fed uncut or unshredded. There are thousands of stockmen, however, who are at present feeding uncut stover, and our own experience along this line convinces us that dairymen would save considerable money by feeding even the uncut stover, rather than purchasing cotton-seed hulls.

While much has been said in favor of feeding corn stover, it should be distinctly understood that the greatest feeding value of the corn plant is obtained when placed in the silo.

COTTONSEED HULLS.

Aside from their low nutritive value cotton-seed hulls do not seem very well suited for dairy cows, on account of their low palatability and digestibility. With the cows used in these experiments it was found that a majority refused the hulls when they were offered them unmixed with concentrated feeds. When mixed with the concentrates the cows would eat them, largely because they were obliged to do so in order to get the concentrates. On general principles it can not be considered good feeding to thus force cows to swallow a lot of unpalatable material, especially when such material has such a low digestibility. Digestion experiments show that only 41 per cent of the total dry matter in hulls is digestible as against 60 per cent for corn stover. Our experiments were of too short duration to show any appreciable digestive disturbances from the feeding of such undigestible material as cotton-seed hulls, but it can not be denied that continuous feeding of any undigestible feed must ultimately prove deleterious to the usefulness of a dairy cow.

CORN MEAL VERSUS A MIXTURE OF CORN MEAL AND DRIED BREWERS' GRAINS AS A SUPPLEMENT TO COTTONSEED MEAL FOR MILK PRODUCTION.

OBJECT OF EXPERIMENT.

A problem that confronts many farmers is to find a cheap and satisfactory grain supplement to cotton-seed meal for dairy cows. Owing to its high protein content, cotton-seed meal can not be satisfactorily used as the sole concentrate, except possibly where silage, made from well-eared corn, constitutes the roughage.

Hitherto wheat bran has been commonly fed in connection with cotton-seed meal and when the latter is not too high priced, this combination gives very satisfactory returns. But during the past year the price of wheat bran has been so high as to make its use as a cow feed almost prohibitive.

A careful study of prices of different feeds suggested the use of either corn meal or dried brewers' grains, or both, as a satisfactory supplement to cottonseed meal. Both of these feeds could be bought at a lower price than wheat bran, and both were believed to have a higher feeding value.

The dried brewers' grains are of a light, fluffy nature and are highly relished by cattle; yet, owing to their high protein content, the objection may be raised that they do not form a balanced ration with cottonseed meal.

From the standpoint of balancing the nutrients in a ration where much cottonseed meal is fed there appears to be no feed more ideal than corn meal. But owing to the heavy nature of both the corn and cottonseed meal a combination of the two would ordinarily be considered liable to give rise to digestive disturbances.

The above possible objection to corn meal and dried brewers' grains suggested that a combination of the two would probably give the most satisfactory results when used to supplement cottonseed meal, and that possibly corn meal alone could be advantageously used for this purpose if no digestive troubles should arise on account of the heavy character of this feed. Accordingly it was decided to test these points by feeding a mixture of corn meal, dried brewers' grains and cottonseed meal in comparison with a mixture of corn meal and cottonseed meal.

PLAN OF EXPERIMENT.

Six grade cows, from three to four weeks in lactation, were used for the experiment. The feeding was divided into three periods. During the first period the cows received cottonseed meal and corn meal in equal proportions. In the second period the cows received a mixture of 4 parts cottonseed meal, 2 parts corn meal and 2 parts

dried brewers' grains. The feed in the third period was the same as that of the first. The daily allowance of grain per cow during the entire test amounted to 10 pounds for cows Nos. 4 and 5, and 9 pounds for cows Nos. 2, 3 and 6. The roughage supplied throughout the test consisted of 14 pounds of shredded corn stover per cow daily. The stover was the same as that used in the Stover and Hull Experiment.

Each period lasted twenty-one days, and only Period I was preceded by seven days preliminary feeding. Closing the experiment with the same ration used at the beginning tended to balance up any changes in milk and butter-fat yield which might be attributable to the advancing stage of lactation, to loss of continuous feeding of unpalatable roughage, to change in weather and other environmental factors.

The grain was always fed before the roughage. The milk from each cow was weighed daily, and weekly samples of the milk were tested by the Babcock test. All cows were weighed regularly once a week.

The results obtained with the individual cows during the different periods of the test are presented in the following tables:

TABLE V.—Showing Milk and Butterfat Yields and Live Weight.

No. Cow.	Period.	Milk—Pounds.	Fat—Per cent.	Butterfat—Pounds.	Average Weight Cows—Pounds.
1	I	528.1	4.36	23.03	721
	II	511.6	4.20	21.49	717
	III	493.4	4.10	20.23	719
2	I	527.1	4.13	21.77	603
	II	459.0	4.30	19.74	606
	III	412.0	4.16	17.14	612
3	I	455.5	4.36	19.86	787
	II	410.8	4.43	18.30	767
	III	390.9	4.26	16.65	784
4	I	542.7	4.40	23.85	724
	II	486.4	4.45	21.64	738
	III	461.3	4.30	19.84	740
5	I	612.8	4.00	24.51	795
	II	528.8	3.90	20.62	786
	III	494.0	3.93	19.41	796
6	I	520.2	.83	19.92	876
	II	462.9	3.80	17.59	854
	III	428.2	3.73	15.97	847

Summarizing the results contained in Table V we find the following:

TABLE VI.—Showing Total Yield of Milk and Butterfat and Total Live Weight.

Period.	Ration.	Milk—Pounds.	Butterfat—Pounds.	Live Weight—Pounds.
I	Corn + Cottonseed Meal	3186.4	132.97	4506
II	Corn + Dried Brewers' Grains + Cottonseed Meal	2859.5	119.38	4468
III	Corn + Cottonseed Meal	2679.8	109.24	4498
Average of Periods I and III		2933.1	121.10	4502

An inspection of the results in the two preceding tables shows there was a gradual falling off in the milk and butter-fat yield of the cows, individually as well as collectively, from the beginning to the end of the test. The decrease was so uniform that it could not, therefore, be attributed to a change in the grain ration, but must be laid to the unpalatable roughage fed. Table VI shows that the average milk and butter-fat yield of Periods I and III, in which corn meal and cotton-seed meal were fed, was slightly larger than that of Period II, in which dried brewers' grains replaced pound for pound one-half of the corn meal fed in Periods I and III.

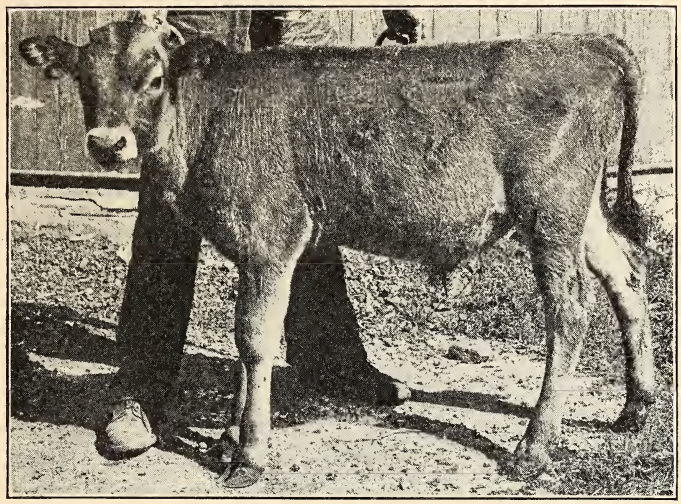
Although no digestive disturbances resulted from the feeding of the combination of corn meal and cottonseed meal, yet the trial was too short to warrant a statement as to what the effects of such a mixure of heavy feeds might be, if fed continuously for a longer time.

Pending further investigation along this line, therefore, we are inclined to recommend to dairymen who are feeding much stover a grain ration consisting approximately of one-half cottonseed meal, one-quarter corn meal and one-quarter dried brewers' grains, or wheat bran, or some similar light, fluffy concentrate, depending upon the market prices of these feeds.

ROLLED OATS AS A SUBSTITUTE FOR MILK IN CALF FEEDING.

One of the essentials in building up a productive dairy herd is to raise the heifer calves from the best milkers. This is also the surest way to keep a herd free from disease. Moreover, where skimmed milk is available for feeding, the practice of raising the best calves is also the cheapest means of increasing and improving the dairy herd.

Hundreds of dairymen, however, who are supplying milk to towns and cities either have no skimmed milk at all or an insufficient quantity for calf rearing. Hence they prefer killing the calves to feeding them high-priced milk. In order to induce this class of dairymen to raise their calves, it became clear to us that some cheap and satisfactory substitute had to be found that would take the place of high-priced milk for feeding.



Grade Calf Reared on Rolled Oats.

In our efforts to find such a substitute, we were guided by the following requirements: that a feed that could take the place of milk for young calves must be very palatable and digestible, rich in muscle and bone-forming materials, and practically free from crude fibre. Cooked rolled oats suggested themselves as meeting all these requirements with the exception, perhaps, that there might be a possible deficiency in ash or bone-forming material. This feed was therefore given a careful test.

It was estimated in the beginning, from the composition of the feeds, that one pound of rolled oats was approximately equal in feeding value to one gallon of whole milk, and our feeding trials were conducted upon this basis. The rolled oats were prepared by adding boiling water to them at the rate of one gallon of water to twelve ounces of rolled oats, and the mixture was then allowed to stand until cool enough to feed.

The feeding of a number of calves was simplified by preparing the rolled oats for all in a can of suitable size, from which the proportionate amount for each calf was measured out with a dipper.

All the calves used in the experiment, with one exception, were grade Jerseys, light to medium in weight. The daily allowance per calf during the thirteen weeks of the experiment was as follows:

First week—10 pounds whole milk.
Second week—8 pounds whole milk, 4 ounces rolled oats.
Third week—6 pounds whole milk, 8 ounces rolled oats.
Fourth week—4 pounds whole milk, 12 ounces rolled oats.
Fifth week—2 pounds whole milk, 12 ounces rolled oats, 0.2 pound grain mixture.
Sixth week—2 pounds whole milk, 12 ounces rolled oats, 0.4 pound grain mixture.
Seventh week—2 pounds whole milk, 12 ounces rolled oats, 0.6 pound grain mixture.
Eighth week—2 pounds whole milk, 12 ounces rolled oats, 0.8 pound grain mixture.
Ninth week—2 pounds whole milk, 12 ounces rolled oats, 1.0 pound grain mixture.
Tenth week—12 ounces rolled oats, 1.0 pound grain mixture.
Eleventh week—12 ounces rolled oats, 1.0 pound grain mixture.
Twelfth week—12 ounces rolled oats, 1.2 pounds grain mixture.
Thirteenth week—12 ounces rolled oats, 1.2 pounds grain mixture.

The grain mixture consisted of one part each of corn meal, linseed meal and wheat bran.

The milk was always added to the oat preparation just previous to feeding.

In addition to the above feeds, the calves received all the hay they would eat during the winter, while in spring they received one feed of hay with pasturage additional.

On the basis that one pound of rolled oats is equal to one gallon of whole milk, and that whole milk is worth 8 cents per quart to milkmen, the cost of the milk for a thirteen-weeks-old calf receiving no rolled oats is $26.96. When rolled oats (which cost 4.4 cents per pound delivered in barrel lots) are substituted for milk as shown above, the cost of the calf feed for the same period is only $12.46, a saving of $14.50 in favor of the rolled oats.

The weekly weights of the calves fed rolled oats and those of two calves fed skimmed milk as a check on the work are presented in the following table:

TABLE VII.—Showing Weekly Gains of Calves Fed Rolled Oats and Skimmed Milk.

Age of Calf.	Weekly Weight of Calves—Pounds.										
	Rolled Oats.									Skimmed Milk.	
	Calf No. 1.	Calf No. 2.	Calf No. 3	Calf No. 4.	Calf No. 5.	Calf No. 6.	Calf No. 7	Calf No. 8.	Calf No. 9.	Calf No. 10	Calf No. 11
At birth	63	83	62	60	62	60	66	50	49	60	46
One week	69	94	70	65	70	------	------	------	------	63	52
Two weeks	78	101	77	70	73	------	------	------	------	74	62
Three weeks	84	106	85	74	74	------	------	------	67	82	67
Four weeks	88	115	88	81	81	------	------	------	------	87	74
Five weeks	94	128	93	86	86	100	------	76	------	97	82
Six weeks	99	131	102	88	90	104	------	------	------	106	90
Seven weeks	108	140	111	91	98	108	------	------	------	115	96
Eight weeks	118	147	120	101	107	114	------	------	------	122	100
Nine weeks	125	159	129	112	115	123	------	------	------	135	113
Ten weeks	139	167	140	122	124	129	------	------	------	146	125
Eleven weeks	151	171	151	134	137	139	144	------	------	159	130
Twelve weeks	170	178	159	141	145	153	154	------	------	170	137
Thirteen weeks	180	188	169	155	155	166	163	168	159	180	146
Average daily gain	1.28	1.16	1.18	1.00	1.00	1.16	1.09	1.30	1.12	1.32	1.10

Skimmed-milk calf No. 10 received the following daily ration:
First week—10 pounds whole milk.
Second week 7 pounds whole milk and 4 pounds skimmed milk.
Third week—4 pounds whole milk and 8 pounds skimmed milk.
Fourth week—2 pounds whole milk, 10 pounds skimmed milk.
Fifth to fourteenth week—14 pounds skimmed milk.

Calf No. 11 received only 8 pounds of whole milk the first week, and subsequently was fed the same allowance of whole milk as calf No. 10, but received 2 pounds less of skimmed milk per day. The grain and roughage for the two skimmed-milk calves were the same as those for calves fed on rolled oats.

Table VII shows that the calves fed on rolled oats made practically the same gains as those fed skimmed milk.

Considering that all calves but No. 2, which was a grade Holstein, were light-weight, common-grade Jersey calves, and that the allowance of whole milk and the rolled oats equivalent were less than is usually fed, the gains here reported are considered as fairly satisfactory. The calves showed good bone and muscle development.

We strongly recommend the feeding of cooked rolled oats to calves for all who either have no skimmed milk or an insufficient

quantity for calf-rearing; and we confidently expect that a trial by such dairymen will result in the rearing of every calf that promises to become a valuable animal in the dairy.

One thing that especially commended itself in the rolled oats feeding was the evident relish with which the calves devoured them. The extra labor entailed in the feeding of the rolled oats was insignificant as compared with the saving effected.

One precaution to observe in feeding rolled oats to calves is not to use it in too large quantities, owing to the laxative character of this feed. Indeed, our experience indicates that it is best not to feed more than 12 ounces daily to each calf. It is important also that the rolled oats and milk be supplied as near the temperature of blood heat as possible.

In these trials the grain was always supplied first and the roughage later, the milk and oats being fed immediately after the grain. The latter was fed from a sterile tin bucket, which was also used for feeding the milk and rolled-oat mixture.

The calves were removed from the cows when twenty-four hours old, and received regularly two feeds daily, except during the first few days, when they were fed three times per day.